THE POTENTIAL OF A BUS RAPID TRANSIT / BUSES WITH HIGH LEVEL OF SERVICE SYSTEM IN METRO ATLANTA: A SUITABILITY AND FEASIBILITY STUDY

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THE POTENTIAL OF A BUS RAPID TRANSIT / BUSES WITH HIGH LEVEL OF SERVICE SYSTEM IN METRO ATLANTA: A SUITABILITY AND FEASIBILITY STUDY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AADT Annual Average Daily Traffic
ALC-BRT across Latitudes and Cultures-Bus Rapid Transit
APTA American Public Transportation Association
ARC Atlanta Regional Commission
BHLS Buses with High Level of Service
BRT Bus Rapid Transit
BTI Breakthrough Technologies Institute
CCT Cobb Community Transit
CID Community Improvement District
CNG Compressed Natural Gas
COST Cooperation in Science and Technology
CTP City Transportation Plan
DPCD City of Atlanta Department of Planning & Community Development
DUI Driving under Influence
GCT Gwinnett County Transit
GDOT Georgia Department of Transportation
GRTA Georgia Regional Transportation Authority
HOT High-Occupancy-Toll
HOV High-Occupancy-Vehicle
ITDP Institute for Transportation & Development Policy
ITS Intelligent Transportation System
LA Los Angeles
MARTA Metropolitan Atlanta Regional Transit Authority
MAP-21 Moving Ahead for Progress in the 21st Century Act
MBTA Massachusetts Bay Transportation Authority
MPO Metropolitan Planning Organization
MMPT Multi-Modal Passenger Terminal
NJ TRANSIT New Jersey Transit
NBRTI National BRT Institute
OD Origin-Destination
O&M Operation & Maintenance
PPHPD Persons per Hour per Direction
ROW Right of Way
RTC Regional Transportation Commission of Southern Nevada
RTP Regional Transportation Plan
SOV Single-Occupancy-Vehicle
TAD Tax Allocation District
TCRP Transit Cooperative Research Program
TOD Transit Oriented Development
TRB Transportation Research Board
TSP Transit Signal Priority
TWLTL Two-Way Left Turn Lane

U.S. United States
WRI World Resource Institute

SUMMARY

The Atlanta Metropolitan Area has been long suffering from traffic congestion, and the ongoing population growth will exacerbate the situation. On the other hand, over half of current transit riders are people from lower-income households and there is a growing senior population more than likely to rely on transit over the next two decades.

One way to mitigate congestion and support transit dependent riders at the same time is to promote transit service. Enhanced bus service systems including Bus Rapid Transit (BRT) and Buses with High Level of Service (BHLS) have been gaining popularity across the world, especially in South and East Asia, Latin America, and Europe. While there are also many BRT systems in the United States, only a few of them actually meet the world standards for providing a dedicated bus lane. Even so, case studies show that there are viable alternatives for implementing successful enhanced transit service:

- Choosing population-activity concentrated corridor;
- Adopting variations of exclusive right-of-way;
- Providing long span and high frequency service; and
- Using off-board fare collection, among others.

Just like the benchmark cases, Metro Atlanta also has corridors with high population density, activity centers, relatively simple straight alignment, but that are currently underserved by bus service. If all the transit agencies, the Georgia Department of Transportation, and City of Atlanta, could work closely with the public to establish an

enhanced bus transit system, traffic conditions in Metro Atlanta would be greatly improved.

INTRODUCTION

This paper employed a two-part approach to explore the potential of an enhanced bus service system in the four counties of Fulton, DeKalb, Cobb, and Gwinnett in metropolitan Atlanta area and answered the following questions:

- If enhanced bus service necessary for the region?
- If necessary, where should such service be implemented?
- How to implement an enhanced bus service system in Metro Atlanta?

The first section introduced a literature review and analysis of relevant work, and the second part used a context sensitivity review and analysis to consider options relevant to metro conditions.

To set the context for the two approaches, the paper began with defining two enhanced bus service categories - Bus Rapid Transit (BRT) and Buses with High Level of Service (BHLS). After conducting a technical comparison of BRT and BHLS, the paper discussed the importance of differentiating the two terms from a public acceptance perspective.

Literature review then considers the major challenges to implement enhanced bus service systems. To ensure that the examples are more transferable to Atlanta, the paper used a case study pool of 57 BRT/BHLS corridors/systems in the United States and finally chose 19 benchmark cases based on ridership change, travel time reduction, user satisfaction, and economic development. Note that a complete list of the 57 cases and the parameters of each

system are included in the Appendix. Comparison among the successful cases showed a lot of similarity on corridor features, service span and frequency, fare collection, and real-time information, yet there are variations due to local context.

In the third chapter, after discussing the necessity of providing transit service in Metro Atlanta from the perspective of population growth and social equity, the paper identified potential BRT/BHLS corridors in the four counties of Fulton, DeKalb, Gwinnett, and Cobb in Metro Atlanta area by using ArcGIS analysis: Georgia Department of Transportation (GDOT) 2010 Annual Average Daily Traffic (AADT) data were utilized to identify the most travelled corridors; 2010 Census data at block group level were used to approximate the population density and minority density along each corridor and to narrow down the candidate pool; and finally a comparison of candidate corridors with existing bus service provided by Metropolitan Atlanta Regional Transit Authority (MARTA), Georgia Regional Transportation Authority (GRTA), Cobb Community Transit (CCT), and Gwinnett County Transit (GCT), and a comparison with proposed managed lane projects and rail capital projects in PLAN 2040 Regional Transportation Plan (RTP), and with high-priority transit projects in Connect Atlanta City Transportation Plan (CTP), were conducted to finalize the candidate BRT/BHLS corridors.

In the last part, based on case study and current condition, the paper discusses the implementation strategies for how to establish an area wide enhanced bus service system in Atlanta through public participation, agency collaboration, service variation, branding,

foresight planning, corridor prioritization, right-of-way acquisition, service span extension, and so on.

CHAPTER 2 LITERATURE REVIEW

2.1 Definition of Bus Rapid Transit (BRT) and Buses with High Level of Service (BHLS)

2.1.1 Definition of Bus Rapid Transit (BRT)

While it is almost four decades since the first BRT system was implemented in Curitiba, Brazil in 1974, the definition of BRT has remained blurred. Even the World Resource Institute (WRI) Center for Sustainable Transport EMBARQ, a non-profit global organization that has worked extensively with local governments and transit agencies in many developing countries from Mexico to Turkey on BRT projects, does not provide a definition of BRT on its website (2013). The National BRT Institute (NBRTI), which is the major research institute dedicated to facilitating the implementation of BRT systems within the United States, defines BRT as "an innovative, high capacity, lower cost public transit solution that can significantly improve urban mobility", and a "permanent, integrated system" using "buses or specialized vehicles on roadways or dedicated lanes to quickly and efficiently transport passengers to their destinations, while offering the flexibility to meet transit demand" (2013). According to the definition by NBRTI, it is difficult to tell what the difference is between regular bus service and BRT, and even what the difference is between BRT and streetcar or trolley.

2.1.1.1 BRT Standard Definition

The Institute for Transportation & Development Policy (ITDP), a non-profit global organization similar to EMBARQ also dedicated to promoting more sustainable transportation modes including BRT, published The BRT Standard Version 1.0 in 2012 and an updated version The BRT Standard 2013 and defined BRT system by the following evaluation criteria in Figure 1.

CATEGORY	MAX SCORE
BRT BASICS (pp. 15–21)	
Busway alignment	7
Dedicated right-of-way	7
Off-board fare collection	7
Intersection treatments	6
Platform-level boarding	6
SERVICE PLANNING (pp. 22–27)	
Multiple routes	4
Peak frequency	3
Off-peak frequency	2
Express, limited, and local services	3
Control center	3
Located in top-ten corridors	2
Hours of operations	2
Demand profile	3
Multi-corridor network	2
INFRASTRUCTURE (pp. 28–32)	
Passing lanes at stations	4
Minimizing bus emissions	3
Stations set back from intersections	3
Center stations	2
Pavement quality	2

	MAX SCORE
STATION DESIGN AND STATION-BUS INTERFACE (pp. 33–36)	
Distance between stations	2
Safe and comfortable stations	3
Number of doors on bus	3
Docking bays and sub-stops	1
Sliding doors in BRT stations	1
QUALITY OF SERVICE AND PASSENGER-INFORMATION SYSTEMS (pp. 37–38)	
Branding	3
Passenger information	2
INTEGRATION AND ACCESS (pp. 39–44)	
Universal access	3
Integration with other public transport	3
Pedestrian access	3
Secure bicycle parking	2
Bicycle lanes	2
Bicycle-sharing integration	1
TOTAL	**100**
BRT BASICS (Minimum Needed: 18)	**33**

Figure 1 BRT Standard Scorecard (ITDP 2013)

With reference to the Standard Scorecard (Figure 1) , to be qualified as a "Basic BRT", a bus system needs to get a minimum total score of 18 for "BRT Basics" on five fundamental elements which are busway alignment, dedicated right of way (ROW), off-board fare collection, intersection treatments, and platform-level boarding. Besides, "Basic BRT" needs to at least score four points for both busway alignment and dedicated ROW (ITDP 2013). The detailed score standards on the five elements are shown in Figure 2 and the minimum requirements on busway alignment and ROW are circled in red.

TRUNK CORRIDOR CONFIGURATIONS	POINTS
Two-way median-aligned busways that are in the central verge of a two-way road	7
Bus-only corridors where there is a fully exclusive right-of-way and no parallel mixed traffic, such as transit malls (e.g. Bogotá, Curitiba, Quito, and Pereira), and converted rail corridors (e.g. Cape Town and Los Angeles)	7
Busways that run adjacent to an edge condition like a waterfront or park where there are few intersections to cause conflicts	7
Busways that run two-way on the side of a one-way street	7
Busways that are split into two one-way pairs but are centrally aligned in the roadway	4
Busways that are split into two one-way pairs but aligned to the curb	4
Busways that operate through virtual lanes produced by a series of bus queue-jump lanes at intersections	1
Curb-aligned busway that is adjacent to the curb	0
TYPE OF DEDICATED RIGHT-OF-WAY	POINTS
Dedicated lanes and full enforcement or physical segregation applied to over 90% of the busway corridor length	7
Dedicated lanes and full enforcement or physical segregation applied to over 75% of the busway corridor length	6
Delineators only or colorized pavement only without other enforcement measures applied to over 75% of the busway corridor length	4
Delineators only or colorized pavement only without other enforcement measures applied to over 40% of the busway corridor length	2
Camera-enforcement with signs only	1

Figure 2 BRT Basics Scorecard (ITDP 2013)

INTERSECTION TREATMENTS	POINTS
All turns prohibited across the busway	6
Most turns prohibited across the busway	5
Approximately half of the turns prohibited across the busway and some signal priority	4
Some turns prohibited across the busway and some signal priority	3
No turns prohibited across the busway but signal priority at most or all intersections	2
No turns prohibited across the busway but some intersections have signal priority	1
No intersection treatments	0

PERCENTAGE OF BUSES WITH AT-LEVEL BOARDING	POINTS
100% of buses are platform level; system-wide measures for reducing the gap in place	6
80% of buses; system-wide measures for reducing the gap in place	5
60% of buses; system-wide measures for reducing the gap in place	4
100% of buses are platform level with no other measures for reducing the gap in place	
40% of buses	3
20% of buses	2
10% of buses	1
No platform-level boarding	0

OFF-BOARD FARE COLLECTION	POINTS
100% of trunk stations have barrier-controlled, off-vehicle fare collection	7
75% + of trunk stations have barrier-controlled, off-vehicle fare collection	6
Proof-of-payment on all routes that touch the trunk corridor	6
60–75% of trunk stations have barrier-controlled, off-vehicle fare collection	5
45–60% of trunk stations have barrier-controlled, off-vehicle fare collection	4
Proof-of-payment on some routes that run on the trunk corridor	3
30–45% of trunk stations have barrier-controlled, off-vehicle fare collection	2
15–30% of trunk stations have barrier-controlled, off-vehicle fare collection	1
< 15% of trunk stations have barrier-controlled, off-vehicle fare collection	0

Figure 2 (Continued)

In summary, while there is some flexibility to qualify as BRT, the bus system needs to meet the following criteria:

1. Having dedicated physical busway (contrary to just queue-jumpers at intersections or transit signal priority (TSP)) for over 75 percent length of the trunk corridor; and

2. Equipped with at least two of the following three features: intersection treatment, off-board fare collection, and platform-level boarding.

2.1.1.2 FTA Definition and Funding Criteria

On the U.S. Federal Transit Administration website, BRT is defined as "an enhanced bus system that operates on bus lanes or other transitways" and "utilizes a combination of advanced technologies, infrastructure and operational investments that provide significantly better service than traditional bus service". While the "significantly better service" is hardly quantifiable, the existence of some sort of transitways has been specified. In the latest federal transportation legislation, the Moving Ahead for Progress in the 21st Century Act (MAP-21), there are three grant programs directly available to BRT projects: New Starts, Small Starts, and Core Capacity. Table 1 summarized the funding eligibility for the BRT targeted grants.

Table 1 Eligibility for Federal BRT targeted transit grants (Vozzolo 2012)

Program	Eligible Projects
New Starts	- Majority operates in separated right-of-way dedicated for transit use during peak periods - Substantial investment in a single route in defined corridor or subarea - Includes features that emulate services provided by rail (defined stations, traffic signal priority, short bi-directional headways, and other features)
Small Starts	- Projects meeting the definition of a fixed guideway for at least 50 percent of the project length in the peak period - Corridor-based bus projects with 10 minute peak/15 minute off-peak headways or better while operating at least 14 hours per weekday.
Core Capacity	- Substantial corridor-based capital investment in an existing investment in an existing fixed guideway system that increase the capacity of a corridor by not less than 10 percent - Corridor must be at or over capacity or projected to be at or over capacity within next five years.

According to the eligibility criteria, at least 50 percent of the corridor needs to have dedicated busways to be considered as BRT.

2.1.2 Definition of Buses with High Level of Service (BHLS)

The concept of Buses with High Level of Service (BHLS) originated in Europe in 2006. The term appeared in the initiative of European Cooperation in Science and Technology (COST) Action TU0603 involving 14 EU countries. It is used to refer to the "Quality Bus Corridor" in England and Ireland, "Bus a Haut Niveau de Service" in France, metro concept in German, and "Hoogwaarding Openbaar Vervoer" in Netherlands, just to name a few. Therefore, BHLS has been created as a term to represent a wide range of enhanced bus services (Finn et al. 2011).

2.1.3 Difference between BRT and BHLS

The differences between BRT and BHLS could be summarized as in Table 2.

Table 2 Comparison between BRT and BHLS

	BRT	**BHLS**
Region	United States, Asia, Latin America	Europe
Full name	Bus Rapid Transit	Buses with High Level of Service
Fundamental difference from traditional bus service	Faster than traditional bus	Better performance than traditional bus in any aspect of speed, reliability, comfort, convenience, etc.
Key feature	Dedicated busway	None

It is notable that some literature used the name "BRT-Lite" to refer to the very beginning of the BRT spectrum, which raises the travel speed by stop consolidation, signal preferential treatment, queue jumper at intersection, to differentiate it from full featured BRT (Rabuel, Heddebaut, and Finn 2010). Meanwhile, some people working in the transit field has realized that some so called BRT systems in the United States are not real BRT, and referred them as "BRT-Lite" instead during his Transit District Board Member election (Roy 2008).

2.1.4 Importance of differentiating BRT and BHLS

From the viewpoint of a transportation planner or engineer, BRT and BHLS both represent improvement on the traditional bus transit system, so rather than focusing on the differences or differentiating the terminology, the time and efforts should be put into the technical part of improvement strategies. However, blueprints will not become reality

without public support, especially in a democratic society like the United States where community consensus is critical to the funding and implementation of any transit project.

A concrete lesson is from the BRT development in Brazil. Following the world's first BRT system in Curitiba, many cities in Brazil implemented dedicated busways but did not equip the system with the full BRT features which shaped the success in Curitiba. None of the followers had been able to replicate the favorable outcome, and a few of them even reduced travel speed and had negative impact on adjacent land value. As a result, the general Brazilians became disillusioned with BRT and no new full-featured BRT systems were built between mid-1980s to 2012 (ITDP 2012).

As the cost and performance of BRT and BHLS could vary dramatically, labeling incremental improvement on bus service as BRT may mislead people into believing that the slight change they experienced is the best the bus service could offer to them. The less-than-accurate advertising may also make people cast doubt on the budget projections of future BRT projects: why does the proposed BRT project need to cost three times more than the previous one? Let alone that the previous "BRT" project does no magic work at all! On the other hand, for those who have a better knowledge of the transit system and its jargon, they may blame or criticize the authority directly (JB 2009, Reed 2012). Either way, the mistrust will poison the public support for the improvement projects, which is the exact reason why professionals should brand the system clearly and cautiously.

To avoid any possible confusion and stress over the difference between BRT and BHLS, in the following part of this paper, the combination of BRT and BHLS are referred to as enhanced bus service, and only enhanced bus service with more than 50 percent dedicated busways on trunk corridor is referred to as BRT while the rest of enhanced bus service is referred to as BHLS.

2.2 Planning and Implementation Process of an Enhanced Bus Service System

2.2.1 Framework

Most enhanced bus transit systems cross multiple jurisdictions' boundaries and require the coordination and collaboration of a wide range of groups, including: Federal, state, local or regional public officials; State transportation, environment, or planning departments; Transit agencies and operators; Local planning, transportation, and economic development agencies; Local traffic engineering or public works departments; Police services involved in safety and traffic enforcement; Private developers or major landowners at station areas; Large private institutions such as hospitals, universities, commercial/retail organizations, or tourism facilities; and Representatives of local environmental or user groups (Levinson, Zimmerman, Clinger, James Gast, et al. 2003).

By May 2012, All the operating enhanced bus services in the US are governed by pre-existing comprehensive regional transit agencies such as the LYMMO in Orlando by Orlando Lynx, MAX in Las Vegas by Regional Transportation Commission of Southern Nevada (RTC), and Silver Line in Boston by Massachusetts Bay Transportation Authority

(MBTA) (NBRTI 2012b). On the other hand, it is common to see commuter bus routes being operated by a separate agency, such as Xpress in Atlanta by Georgia Regional Transportation Authority (GRTA) while the rail and bus agency in Atlanta metropolitan area is Metropolitan Atlanta Regional Transit Authority (MARTA). And Commuter service from New Jersey to New York City is provided by ACADEMY while most rail and bus services in New Jersey are provided by New Jersey Transit (NJ TRANSIT).

2.2.2 Major Challenges

Currently, there are more than 30 cities and counties in the U.S. running enhanced bus transit systems (ALC-BRT and EMBARQ 2013a, NBRTI 2012b). The following part summarizes the major obstacles to implement enhanced bus service and the solution or middle ground the cities have arrived at.

2.2.2.1 Space: Right of Way (ROW) & Busway Alignment

2.2.2.1.1 Difficulty in Acquiring the Optimum ROW & Busway Alignment

While in general dedicated bus lanes could significantly improve bus travel speed, it could be hard to have depending on the right of way, built environment along the corridor, current lane configuration, and construction cost. On the other hand, the ridership of the corridor and/or the service frequency may not justify the need of adding transit dedicated lanes or taking lanes away from general traffic.

The same rule applies to busway alignment. While it is most beneficial to bus travel speed to have the median-aligned busways (Figure 3), and have as few as possible intersections

along the corridor, or even have exclusive right-of-way, the cost in terms of capital investment or the delay experienced by general traffic could be prohibitive.

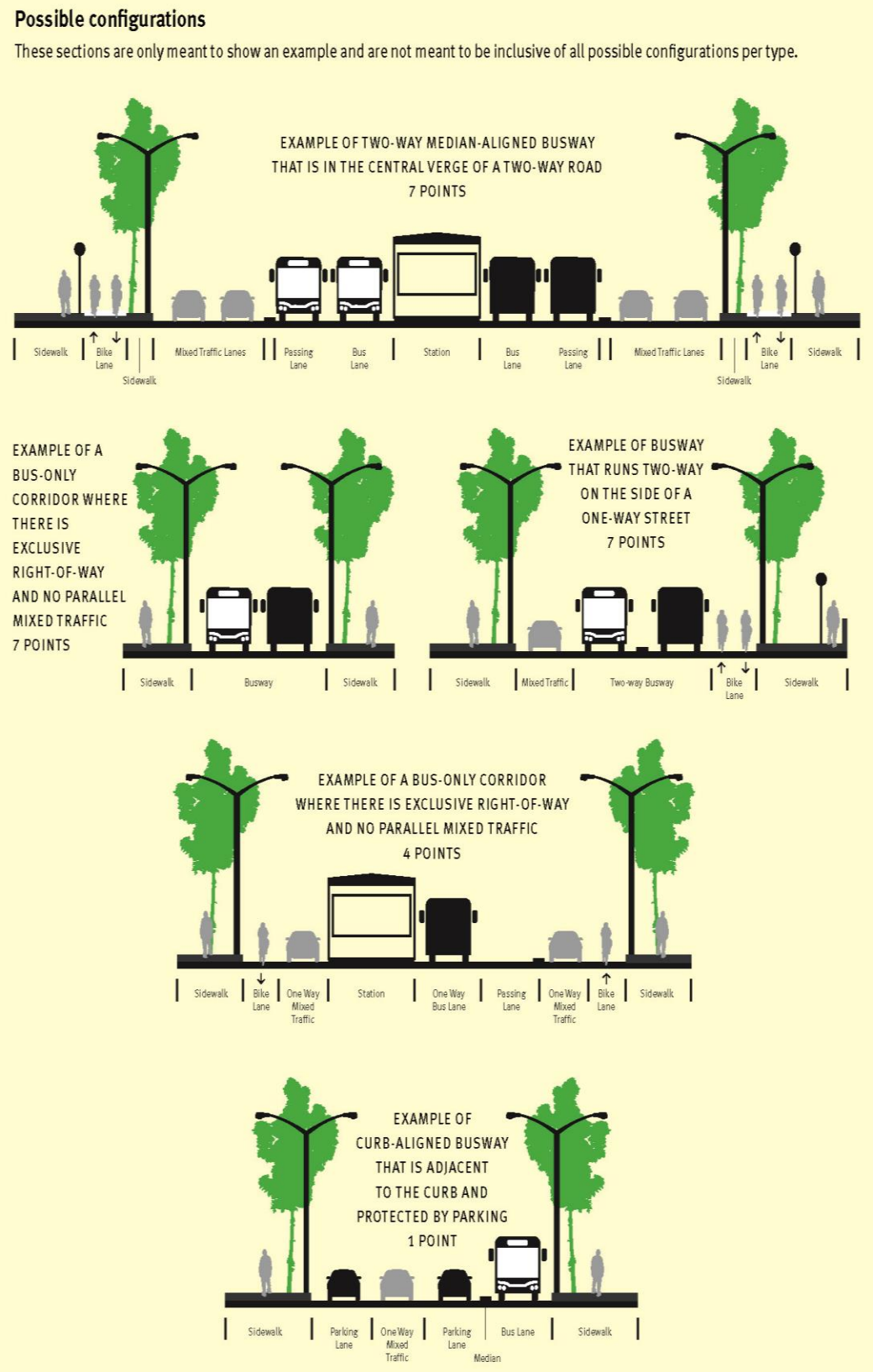

Figure 3 BRT system possible lane configuration (ALC-BRT and EMBARQ 2013a, NBRTI 2012b)

As a result, among all the operating bus routes by the middle of 2013 in the US, only the following corridors in Table 3 have dedicated bus lanes. Note that Table 3 does not include any peak hour busways, semi-dedicated lanes, or HOV/HOT lanes.

Table 3 Dedicated bus lanes in the United States

Brand	Place	ROW and Lane Alignment
Marq2	downtown Minneapolis	Two lane side-by-side busways on one way street; using original contraflow bus lanes
Silver Line	Boston	Partly in bus dedicated tunnel
LYMMO	Orlando	Busways that are split into two one-way pairs and aligned to the curb
South Miami-Dade Busway	Miami	Two way two lane exclusive roadway on the ROW of previous Florida East Coast Railroad line
EmX	Between Downtown Springfield and downtown Eugene	60% of the route has dedicated median two way bus lanes. one portion is a two way reversible bus lane using block signaling system similar to rail operation
Valley Metro	Pittsburgh	Two-lane bus only highway
Metro Orange Line	Los Angeles	Majority are dedicated transitways on rail ROW
MAX	Las Vegas	4.5 miles out of 7 miles use curbside dedicated lane sharing with right-turning vehicles
Healthline	Cleveland	Busways that are split into two one-way pairs and are centrally aligned in the roadway
SWIFT	Snohomish County	7 miles of dedicated curbside lanes and 10 miles in mixed traffic
Cedar Avenue BRT	Minneapolis - Saint Paul	Bus only shoulder lane
West Busway	Pittsburgh	Two lane dedicated bus-only highway
South Busway	Pittsburgh	Dedicated lane through trolley ROW; joint-use bus/light rail transit tunnel
East Busway	Pittsburgh	Two lane dedicated bus-only highway parallel to railroad ROW
3500 South Max	South Lake City	One mile out of 10 miles has dedicated center-aligned lane

2.2.2.1.2 Alternatives to dedicated busways

The good news is that dedicated bus lanes seem not to be a must to decrease travel time or increase ridership (Table 4). Among the systems listed below, Los Angeles (LA), Miami, Brisbane, and Vancouver have full-length dedicated busways; Boston is a semi-dedicated corridor, where the buses have a dedicated tunnel and then merge into general traffic; and Oakland shares the lane with other vehicles through the whole system. Yet, compared to their peers with advanced ROW, the systems in Boston and Oakland experienced similar ridership increase and travel time reduction.

Table 4 Ridership and travel time change in enhanced bus systems (TCRP 2007)

Location	% Corridor Ridership Gain	Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Los Angeles	40	3 years	25	>30
Miami	85	5 years	30	>50
Brisbane (Australia)	60	2 years	NA	>45
Vancouver (BC)	30	2 years	16	>25
Boston	100	18 months	20-30	>30
Oakland	20*	1 year	17	>30*

* Offset to seasonal decline

Also, besides continuous dedicated busways, there are alternatives to provide lane usage priority to buses. One strategy is to provide bus only lanes in short segments such as queue-jumper lanes (Agrawal, Goldman, and Hannaford 2012). Another strategy is to share the bus lanes with limited types of lane users and/or during certain hours such as semi-dedicated lanes, High-Occupancy-Vehicle (HOV) / High-Occupancy-Toll (HOT) lanes, and peak hour busways. Semi-dedicated lanes are commonly designed with side reservation, which could accommodate buses, bicycles and right-turning vehicles (Ivany

2004). High-Occupancy-Vehicle (HOV) and High-Occupancy-Toll (HOT) lanes allow buses to pass congested traffic in general travel lanes during peak hours with motorcycles, electric vehicles, and other high occupancy vehicles. Priority use during designated hours such as peak hour busways could be adopted with allowance for certain other vehicles too (Agrawal, Goldman, and Hannaford 2012).

2.2.2.1.3 Median-aligned versus Curb-aligned

While the BRT Standards give median-aligned configurations a much higher score than curb-aligned (Figure 3), a study shows the best configuration depends on the traffic pattern. This study extensively examined the costs and benefits of using a two-way left turn lane (TWLTL) on a congested street for Bus Rapid Transit during peak times of the day. Two options were explored: a median BRT or a curbside BRT with conversion of the TWLTL to a reversible general-purpose lane. Computer simulations of different scenarios with varied intersection designs and movement volumes show that the preferred type of service largely depends on turning volumes at each intersection: larger left-turn volumes favor curbside service; and larger right-turn volumes favor median service. A table (Table 5) is provided to assist planners in choosing the best mode of BRT based on left- and right-turn volumes (Liu, Zhang, and Wang 2013).

Table 5 Guidance chart that considers traffic volumes for BRT alignment alternatives (Liu, Zhang, and Wang 2013)

Right-Turn Volume (vphpl)		200	300	400	500	600	700	800	900	1000	1100	1200
Left-Turn Volume (vphpl)		↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
200	→	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-M F-C M-C	N-M F-C M-C	N-M F-C M-C	N-M F-M M-C	N-M F-M M-C	N-M F-M M-C
250	→	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-M F-C M-C	N-M F-C M-C	N-M F-C M-C	N-M F-M M-C	N-M F-M M-C	N-M F-M M-C
300	→	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-M F-C M-C	N-M F-C M-C	N-M F-C M-C	N-M F-M M-C	N-M F-M M-C	N-M F-M M-C
350	→	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	Widen Intersection, Add Turn Bay, Increase Number of Phases, Increase Cycle Length					
400	→	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C						
450	→	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C						
500	→	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C	N-C F-C M-C						
LEGEND	First Letter: N=Near Side, F=Far Side, M=Mid Block Second Letter: C = Use Curb BRT Lane, M = Use Median BRT Lane											

2.2.2.2 Funding Sustainability

A major advantage of enhanced bus service system over any rail system including heavy rail, light rail, commuter rail, or streetcar, is the relatively low capital cost. In Orlando, LYMMO BRT system cost $21 million to build, and it is half the projected cost of the proposed streetcar system (Kimbler 2005). According to the case study in the Transit Cooperative Research Program (TCRP) report (Levinson, Zimmerman, Clinger, Rutherford, et al. 2003) for enhanced bus service systems, “the reported median costs were $272 million per mile for bus tunnels (2 systems), $7.5 million per mile for busways (12 systems), $6.6 million per mile for arterial median busways (5 systems), $4.7 million per

mile for guided bus operations (2 systems), and $1 million per mile for mixed traffic or curb bus lanes (3 systems)". Table 6 and Figure 4 show the cost composition of several existing enhanced bus systems. Acquisition of right-of-way (ROW) and lane construction usually make up the largest portion of the cost, followed by station installation/improvement and vehicle purchase. Intelligent technology systems (ITS) and fare collection are relatively cheap to implement.

Note that when the capital cost differences are marginal, enhanced bus service systems will lose one of its most competitive advantage over other modes, also the funding may become problematic. Boston had been planning on a downtown tunnel to connect Washington Street and Waterfront since 2002. But as the estimated cost rose to $2.1 billion, FTA finally assigned it a Medium Low overall rating in 2009 and made it impossible to move into the final design phase for federal New Starts Funding.

Table 6 Cost of enhanced bus service system in the United States (Helen M.Tann 2009)

City	Boston		Eugene	Las Vegas	Los Angeles		Sacramento	San Jose
BRT Line / System	Silver Line Washington St	Silver Line Waterfront	EmX	MAX	Orange Line	Metro Rapid (All Routes)	EBus - Stockton	Rapid 522
Year of Opening	2002	2005	2007	2004	2005	2000-today	2004	2005
Length of Route (mi)	2.4	4.5	4.0	7.5	14.5	229.5	8.0	25.0
Total Capital Cost by Route	$27.29 m	$618 m	$23.5 m	$20.16 m	$318 m		$7.95 m	$3.5 m
Running Way	$8.44 m	$572.2 m	$18 m for all design and construction	$0.04 m	$180 m			$2.7 m
Stations	$5.0 m	included in Running Way		$5.45 m	$40 m	$50,000 per station	$0.80 m	minimal, used existing stops
Vehicles	$13.85 m	$42.2 m	$6.5 m	$12.10 m	$16 m	$350,000 per bus	$3.8 m	$130,000 to wrap existing vehicles
ITS			Included in $18 m	$0.57 m	$10 m	$100,000 per mile	$1.8 m	Included in other VTA projects
Fare Collection				$2.00 m	$6 m			No extra investment needed
Other		$9.60 m			$66 m		$1.55 m	$550k for planning and project management

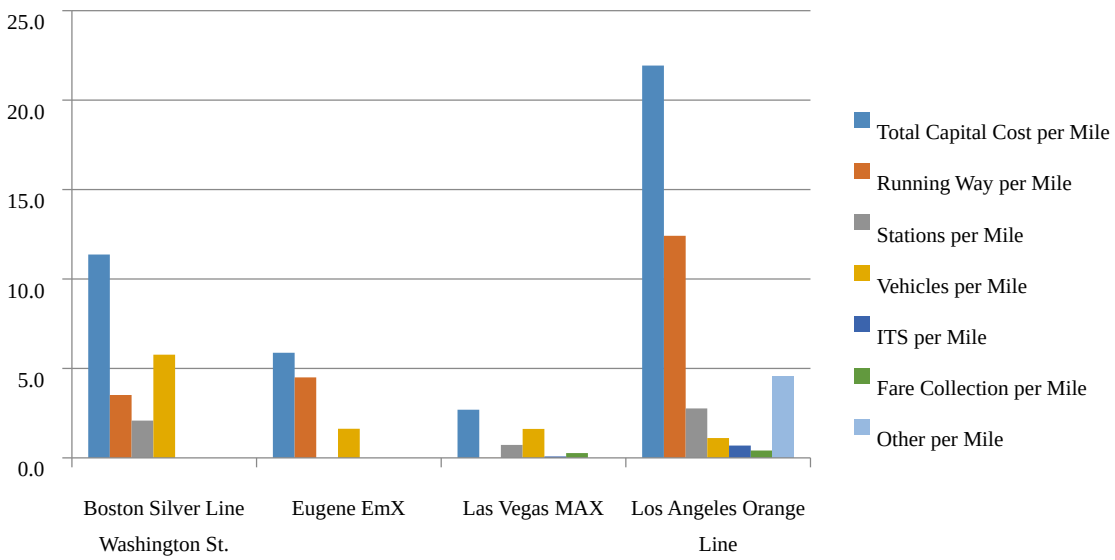

Figure 4 Cost of enhanced bus service systems in the United States (Helen M.Tann 2009)

Due to the varied social and political landscape, the breakdown of capital funding from federal, state, and local source differs greatly from one system to another. As for the operations and maintenance coverage, the LYMMO system in Orlando is a good example, which is funded by the Community Redevelopment Agency and the City of Orlando parking system (Kimbler 2005).

2.2.2.3 Ridership Increase

Ridership is usually positively correlated with fare revenue, which matters for financial sustainability, and it is also a measurement of mode shift and user acceptance. Therefore, increasing ridership is both a goal for an enhanced bus service system and a key to its success.

Ridership increase could be attributed to a series of factors (Table 7). While running ways make the largest contribution, branding can make up to 10 percent of ridership increase too. Stations, vehicles, service patterns, and ITS applications are the factors in between. Note that the implemented systems show that headway and travel time deduction have varied impact on ridership increase in different corridors (Table 8).

Table 7 Headway and travel time change effects on ridership increase (TCRP 2007)

Component	Maximum %
Running ways	20%
Stations	15%
Vehicles	15%
Service patterns	15%
ITS applications	10%
Branding	10%
Subtotal	*85%*
BRT component synergy (when subtotal is 60 or more)	15%
Total	*100%*

Source: Estimated by TCRP research team

Table 8 Headway and travel time change effects on ridership increase in existing systems (TCRP 2007)

	Los Angeles Metro Rapid		Vancouver	Boston
Ridership Increase	Ventura Blvd	Wilshire-Whittier Blvd	B-Line #98	Silver Line
Weekday	2,850 riders[1]	20,660 riders[1]	4,000[2]	2,290[3]
	26%	33%	29%	30%
Due to headway changes	6%	8%	9%	7%
Due to travel time changes	10%	12%	6%	2%
Due to other changes	10%	13%	14%	21%

[1] SOURCE: *TCRP Report 90* (*12*)

[2] SOURCE: APTA Intermodal Operations Planning Workshop (*13*)

[3] SOURCE: MBTA counts

2.2.2.4 Public Support & User Satisfaction

2.2.2.4.1 Public Support

As mentioned before, political and public support before implementation is closely related to funding availability and user satisfaction afterwards. Compared to many other parts of the world, U.S. cities also face the challenge of the strong preference for rail transit over bus transit ((Levinson, Zimmerman, Clinger, James Gast, et al. 2003).

In one of the best-accepted systems, Eugene BRT, full community buy-in was identified as the prerequisite of system design and implementation and the project success was built on the attractiveness to riders rather than punitiveness on other modes. Several levels of participation influenced the process: charrettes involving elected officials, community members, design professionals, and jurisdictional staff; individual meetings with property owners; and collaboration between traffic engineers from the jurisdictions and staff from the transit agency (Carey 2006).

Boston is another example to show how to meet community needs, while the needs may change over time. The planning stage gained public support by incorporating the public preference for curbside reservation with wider sidewalk and on-street parking, as well as station locations. This project also shows the dynamic and flexibility of public opinions: the community agreed to add in more crosswalks when new residential developments began to happen although initially they tried to minimize them (Ivany 2004).

2.2.2.4.2 Public Support

As for user satisfaction, besides the more obvious factors such as decrease in travel time and increase in reliability, built environment could play a significant role. In Orlando, the implementation of LYMMO system includes a major program of physical improvements on streetscape, landscape and safety. The high quality of bus service and enhanced physical appearance of service area even have stimulated economic growth and residential development (Kimbler 2005).

2.3 Case Study of enhanced bus service systems in United States

2.3.1 Case Pool

The case pool was drawn from three BRT databases: brtdata.org produced by across Latitudes and Cultures-Bus Rapid Transit (ALC-BRT), EMBARQ and their partners, gobrt.org produced by Breakthrough Technologies Institute (BTI), and nbrti.org produced by National BRT Institute. The brtdata.org provides a database of worldwide BRT systems including those in the United States (ALC-BRT and EMBARQ 2013b). It has the most comprehensive indicators table although not all the specifics about each corridor are available. The ALC-BRT and EMBARQ's database is also up to date with some of the latest data added in 2013. The gobrt.org has an extensive pool of America's systems, and some of the description is in great detail, including funding information. The only problem with gobrt.org is that it has stopped updating with the latest data updated to 2008 (BTI 2008), and so some information is outdated. The nbrti.org provides two detailed lists of currently operating BRT systems (NBRTI 2012b) and BRT systems to be implemented

(NBRTI 2012a) updated to 2012 May. Note that while these three databases are all named after BRT, according to the definitions of BRT and BHLS discussed in Section 2.1, most systems are BHLS instead of BRT. To avoid confusion, all the cases are referred to as enhanced bus service in the following part of Section 2.3.

After the establishment of a 58 case pool from the three online databases, more up to date information was gather from each system operating or planning agency. An extensive spreadsheet was developed and attached to this paper in APPENDIX: Enhanced Bus Service Systems in the U.S. 2013. All the data in the appendix are from either the three online databases (mentioned above) or the corresponding transit agency website unless otherwise specified. And the reference in the following part discussion in Section 2.3 is APPENDIX unless otherwise specified.

2.3.2 Identify Benchmark Cases

Based on corridor performance measurements such as ridership increase (Figure 5), travel time reduction (Figure 6), new riders attracted, users' satisfaction, and economic development stimulated, a series of benchmark cases were selected. Table 9 shows the system list and the selected reason. Note that due to data availability, the list was not intended to be inclusive.

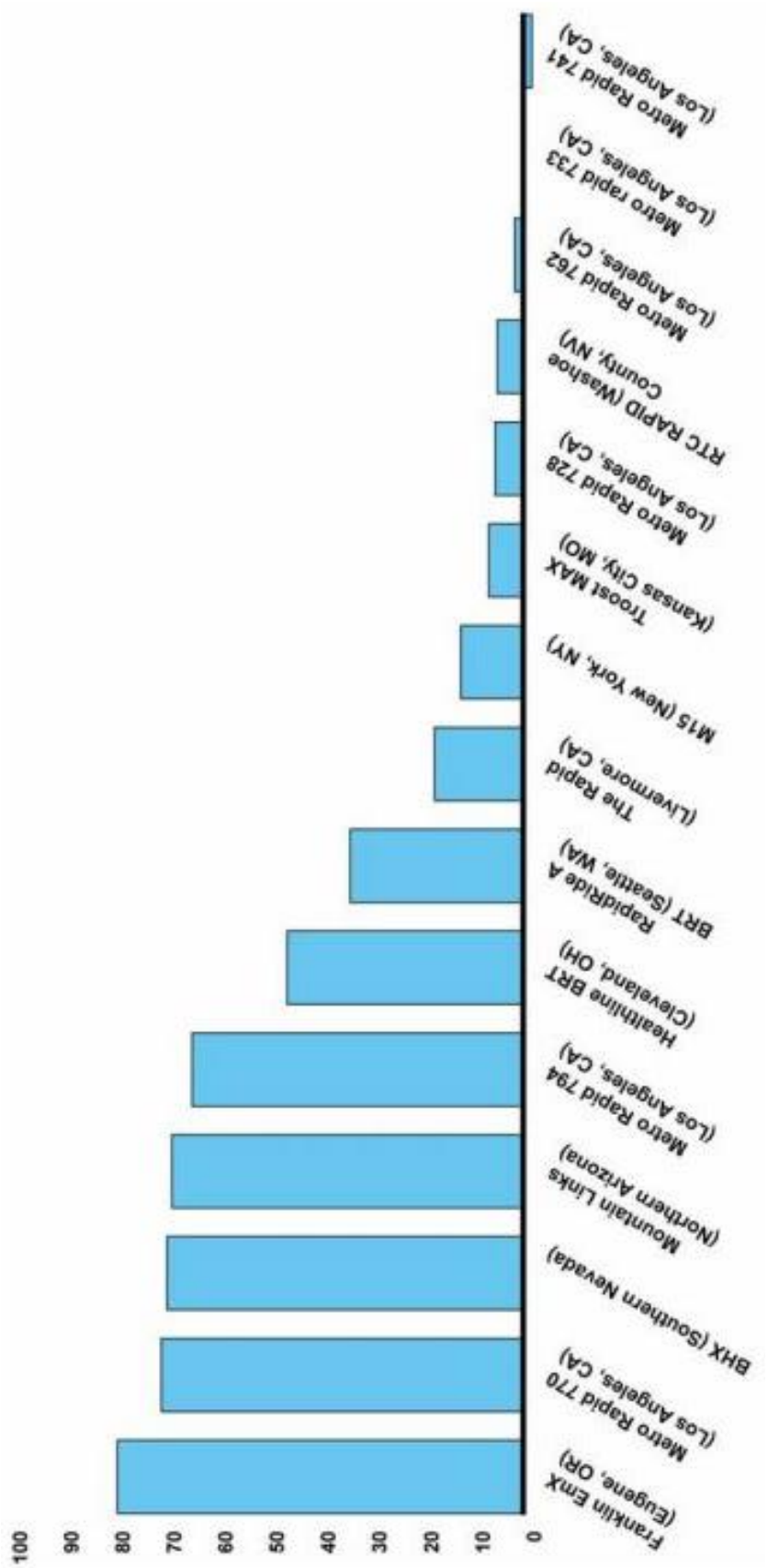

Figure 5 Percentage Change in Ridership of Enhanced Bus Service Projects after 1 Year of Operation Compared to Previous Transit Service (Source GAO analysis of tranist agency reported data) (Johnson and Shelby 2012)

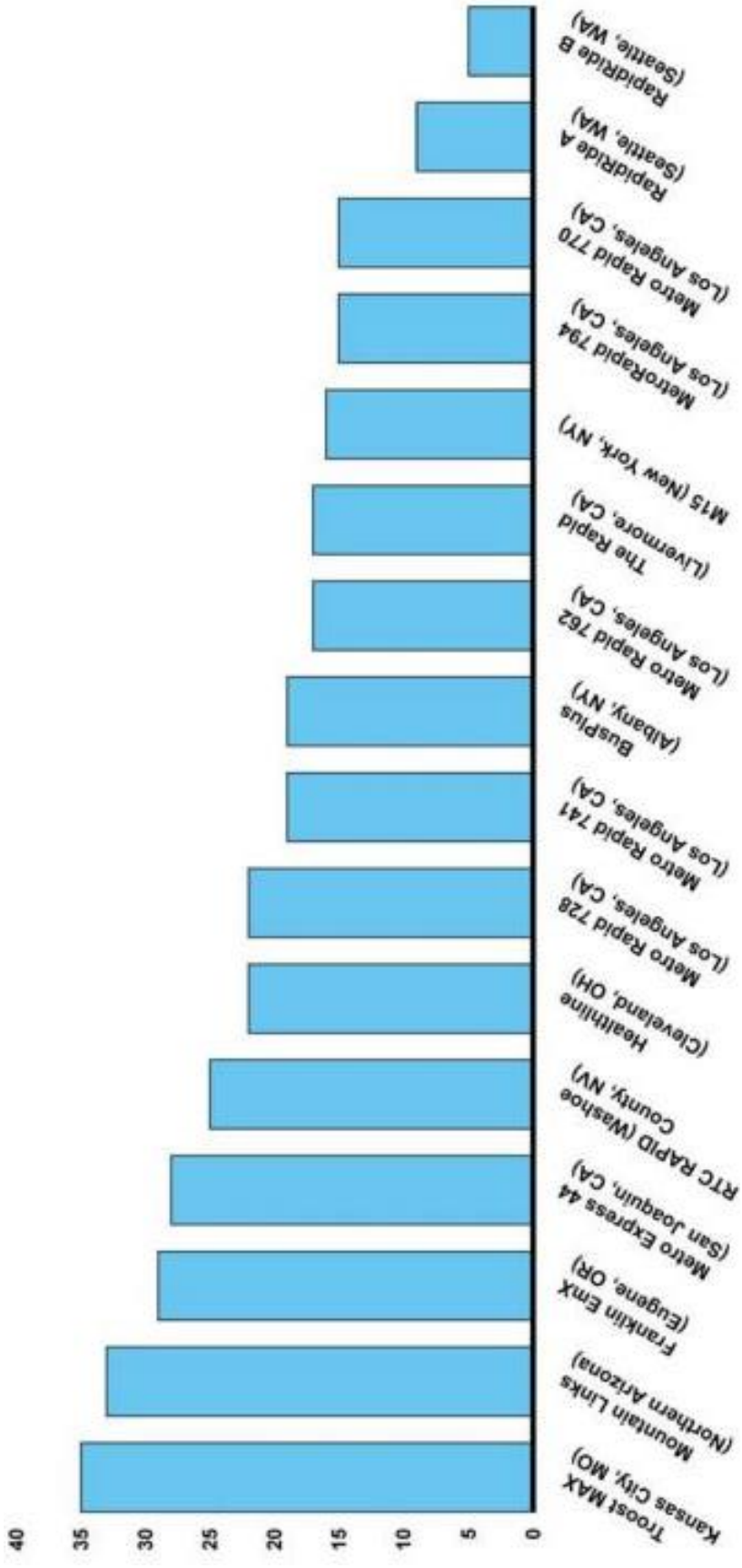

Figure 6 Travel Time Savings of Enhanced Bus Service Projects (Source: GAO analysis of transit agency reported data) (Johnson and Shelby 2012)

Table 9 Benchmark Cases of Enhanced Bus Service Systems in the U.S.

Benchmark Cases	Reason
Cleveland Healthline (Euclid Corridor, OH)	• High average weekday ridership (15800 in 2013) • Estimated $4-$5 billion investment has occurred in the corridor although much is associated with nearby institutions
Franklin EmX (Eugene, OR)	• 35% corridor ridership increase and 4% corridor travel time deduction in the first14 months • Although it is hard to measure the EmX contribution, but $100 million worth of projects are underway in the corridor • The success set up base for the implementation of EmX Springfield Gateway and current upgrading
EmX Springfield Gateway (Eugene, OR)	• 39% corridor ridership increase in
Snohomish County SWIFT bus rapid transit (WA)	• 11% corridor ridership increase in first year • Average weekday ridership has been keeping going up (1699 in Dec 2009; 2660 in Feb 2010; 4300 in 2012)
Kansas City Metro Area Express (MAX) – Main (MO)	• 30% corridor ridership increase in first year • $12.3 million federal grant in 2005 and $6.3 in 2007 were awarded for expansion • $25 million federal grant for urban reinvestment on Troost Ave partly due to the BRT system • On board survey in 2005: MAX is rated excellent on all 20 factors • Rider survey in 2007: MAX is rated above 8 (1 worst -10 best) on all criteria
Strip and Downtown (SDX) (Las Vegas, NV)	• 25% corridor ridership increase in first 5 months • 37% travel time deduction compared to pre-MAX standard bus service
Los Angeles Metro Rapid (CA)	• First enhanced bus service line in Los Angeles opened in 2000 and it is success led the implementation of later routs • 40% corridor ridership increase • 29% travel time reduction • 33% new transit riders
901 Metro Orange Line (Los Angeles, CA)	• 17% Orange Line ridership increase is new transit trips • Metro staff attributed a few development projects to the Metro Rapid Lines, but noted that the routes were put into corridors had concentrated development already • Rider survey in 2006 showed overwhelming approval of Orange Line's features and time-savings
South Miami-Dade Busway (Miami, FL)	• 10 years after opening (1997-2007), average weekday ridership increased by 179% and reached 23000 • Gained support for extension in 2005 and 2007

Table 9 (Continued)

Benchmark Cases	Reason
Metro Red Line (Cedar Avenue BRT, Minneapolis / Saint Paul, MN)	• Average weekday ridership was 835 two months after opening, which is 86% of the goal set for the end of the first year of service
New York Route 905 BUSPLUS (Albany-Schenectady, NY)	• 11 months after opening, corridor ridership increased by 13% and travel time reduced by 25%
M15 First/Second Avenues SBS (NY)	• 2010 (opening year)-2011, average weekday ridership reached 35000 and corridor ridership increased by 9% • 2011-2012, average weekday ridership reached 57000 and corridor ridership increased by 42% • In first year, travel time reduced by 15% • On-board survey in 2011 indicated 99% riders are "satisfied" or "very satisfied"
M34/M34 A SBS (NY)	• 2008 (opening year)-2012, travel time reduced by 10% • Average weekday ridership is 18000 in 2012 and 22000 in 2013
B×12 Fordham Road SBS (NY)	• Corridor ridership increased by 7% in one year • 19% travel time reduction compared to B12 limited
Lynx Lymmo (Orlando, FL)	• Fee Free since the opening of 1997
Pittsburgh West Busway (PA)	• 26 months after opening, corridor ridership increased by 135% • 85% riders reported total travel time has been reduced by an average of 14 minutes
Pittsburgh South Busway (PA)	• Opened in 1977 and its success created the opportunity for the implementation of West Busway and East Busway
Salt Lake 3500 South Max (UT)	• After adding 1 mile of dedicated lane in 2010 (Opened in 2008), corridor ridership increased by 100%
Seattle RapidRide-A Line (WA)	• Corridor ridership increased by 25% three months after opening • 84% customer satisfaction three months after opening

2.3.3 Case Study

2.3.3.1 Similarity

2.3.3.1.1 Corridor feature

All the identified systems are implemented in four type of corridors (Table 10):

- Within a downtown area or linking two downtown areas such as Fanklin EmX, Las Vegas SDX, Demonstration Program of Los Angeles Metro Rapid, New York Route 905 BUSPLUS, M15 First/Second Avenue SBS, M34/34 A SBS, Lynx Lymmo;
- Linking suburban to downtown such as: EmX Springfield Gateway, Kansa City MAX-Main, Metro Red Line-Cedar Avenue BRT, Pittsburgh West Busway, Pittsburgh South Busway
- Linking activity centers such as Cleveland Healthline, Snohomish County SWIFT bus rapid transit, 901 Metro Orange Line, B×12 Fordham Road SBS, Seattle RapidRide-A Line;
- Linking suburban and /or activity centers to major transit connection point such as: South Miami-Dade Busway, M15 First / Second Avenue SBS, M34 /M34 A SBS, Salt Lake 3500 South MAX, Seattle RapidRide-A Line

In summary, activity-activity and /or activity-transit connection mode is shared by all the successful corridors.

Table 10 Corridor Feature of Benchmark Cases

Benchmark Cases	Corridor
Franklin EmX	• Linking downtown Springfield and downtown Eugene
Strip and Downtown (SDX)	• Between old downtown and strip (concentration of casinos, restaurants, and hotels)
Los Angeles Metro Rapid	• Demonstration Program was implemented in two key corridors
New York Route 905 BUSPLUS	• Linking downtown Albany and downtown Schenectady
M15 First/Second Avenues SBS	• Linking South Ferry and 125th Street
M34/M34 A SBS	• Linking East 34th Street Ferry Terminal and 12th Avenue
Lynx Lymmo	• Running in Downtown Orlando
EmX Springfield Gateway	• downtown Springfield to medium density residential area and a major shopping center
Kansas City Metro Area Express (MAX) - Main	• Cross-region routes and express service to downtown and suburban job sites
Metro Red Line (Cedar Avenue BRT)	• Linking the communities of Lakeville, Apple Valley, and Eagan to the Mall of America (MOA), MSP Airport, and downtown Minneapolis (via Blue Line connection at the MOA)
Pittsburgh West Busway	• Linking downtown Pittsburgh and Carnegie
Pittsburgh South Busway	• Linking downtown Pittsburgh and South Hills
Cleveland Healthline (Euclid Corridor)	• With high concentration of hospitals and universities
Snohomish County SWIFT bus rapid transit	• between Everett and Shoreline
901 Metro Orange Line	• Linking North Hollywood, Van Nuys, Canoga Park, and Chatsworth
B×12 Fordham Road SBS	• Broadway-Inwood and Bay Plaza
Seattle RapidRide-A Line	• Linking SeaTac and Federal with many public facilities along the route and ending at two major connection points: Federal Way Transit Center and Tukwila International Blvd. Station
South Miami-Dade Busway	• Linking Metrorail with Cutler Ridge, Naranja, and Florida City
Salt Lake 3500 South Max	• Between 3300 South TRAX Station and Magna

2.3.3.1.2 Service Span

As shown in Table 11, in general all of the benchmark cases have long service spans, and run seven days a week except Salt Lake 3500 South MAX and Snohomish County SWIFT bus rapid transit which have no service on Sundays. Note that the inbound and outbound services usually start and end at different times, so the service span of each system shown here is an approximate time.

Table 11 Service Span of Benchmark Cases

Benchmark Cases	Service Span
Franklin EmX	5:40AM-11:00PM on Weekday; 6:50AM-11:00PM on Sat; 7:45AM-8:20PM on Sun
Strip and Downtown (SDX)	9AM to midnight daily; Has a local route Deduce with more stops running 24/7
Los Angeles Metro Rapid	Multiple routes
New York Route 905 BUSPLUS	5:00AM-11:30PM on Weekdays; 7AM-10PM on Sat; 8AM-5PM on Sun
M15 First/Second Avenues SBS	5AM-10PM with local service 24/7
M34/M34 A SBS	5AM-1AM Daily
Lynx Lymmo	Mon – Thurs: 6AM – 10PM Fri: 6 AM-midnight Sat:10AM-midnight Sun:10AM – 10PM
EmX Springfield Gateway	5:40AM-11:00PM on Weekday; 6:50AM-11:00PM on Sat; 7:45AM-8:20PM on Sun
Kansas City Metro Area Express (MAX) - Main	5AM-1AM everyday
Metro Red Line (Cedar Avenue BRT)	5AM-11PM on Weekdays; 7AM-11AM on Weekends and Holidays
Pittsburgh West Busway	5AM-11PM on Weekdays; 6AM-11PM on Sat; 6:30AM-11:00 PM on Sun
Pittsburgh South Busway	Multiple routes
Cleveland Healthline (Euclid Corridor)	24/7
Snohomish County SWIFT bus rapid transit	5AM-7PM Mon-Sat; no service on Sun

Table 11 (Continued)

Benchmark Cases	Service Span
901 Metro Orange Line	4AM-12AM daily; Service covers late Fri and Sat night
B×12 Fordham Road SBS	5AM-11PM with local service 24/7
Seattle RapidRide-A Line	24/7
South Miami-Dade Busway	Multiple routes
Salt Lake 3500 South Max	4:20AM-10:30PM on Weekdays; 5:00AM-11:00PM on Sat; no service on Sun

All systems except Snohomish County SWIFT bus rapid transit operate over 15 hours and above on weekdays, which could serve a broad range of trip purposes and indicates more than two drivers are assigned to each bus. Cleveland Healthline and Seattle RapidRide-A Line run 24/7, so they could serve full range of travel purposes and can potentially replace riskier travel such as Driving under Influence (DUI). They are followed by New York Route 905 BUSPLUS, M34/M34 A SBS, Kansa City Metro Area Express (MAX)-Main, Metro Red Line (Cedar Avenue BRT), Pittsburgh West Busway, 901 Metro Orange Line, B×12 Fordham Road SBS, Salt Lake 3500 South Max, which operate 18 hours or above on weekdays and can serve similar range of purposes. It is remarkably that Strip and Downtown (SDX), M15 SBS, B×12 SBS have local 24/7 service as a supplement to realize full coverage.

All systems operate more than 15 hours on Saturday except Lymmo (14 hours) and have equal or slighter short service span on Sunday except Salt Lake 3500 South MAX and Snohomish County SWIFT which don’t run on Sundays. It is noticeably that some systems even have expanded service on weekends and holidays or provide late service by adjust the

timetable: Lymmo in downtown Orlando runs till midnight on Friday and Saturdays; 901 Metro Orange Line linking North Hollywood, Van Nuys, Canoga Park, and Chatsworth in LA provides late service on Friday and Saturdays; South Lake 3500 South Max starts and ends its service about half hour later on Saturdays.

2.3.3.1.3 Service frequency

Except for Pittsburgh West Busway and Salt Lake 3500 South Max, all systems use varied headways for peak hour and non-peak hour. Note that each system defines peak hours differently, so the headway breakdown in Table 12 was intended to show a general period rather than being accurate.

Table 12 Service Frequency of Benchmark Cases

Benchmark Cases	Headway (in minutes)			
	AM Peak	AM Off Peak	PM Peak	PM Off Peak
Franklin EmX	10	10	10	10
Strip and Downtown (SDX)	12	15	12	15
Los Angeles Metro Rapid	3-10	-	3-10	-
New York Route 905 BUSPLUS	15	30	15	30
M15 First/Second Avenues SBS	5	10	5	10
M34/M34 A SBS	6/7	8/9	7/10	10/20
Lynx Lymmo	5	10	5	10
EmX Springfield Gateway	10	15	10	15
Kansas City Metro Area Express (MAX) - Main	9	15	15	30
Metro Red Line (Cedar Avenue BRT)	15	15	20	20
Pittsburgh West Busway	15	15	15	15
Pittsburgh South Busway	15	20	15	20
Cleveland Healthline (Euclid Corridor)	5	15	5	15
Snohomish County SWIFT bus rapid transit	12	20	12	20
901 Metro Orange Line	4	7	4	8
B×12 Fordham Road SBS	5	10	5	10
Seattle RapidRide-A Line	10	15	10	15
South Miami-Dade Busway	-	-	-	-
Salt Lake 3500 South Max	15	15	15	15

Peak hour headways on weekdays of all systems are less than 15 minutes, shorter than the general standard of high frequency in the U.S. which is 15-20 minutes. Half of the identified systems adopted peak hour headways that are equal to or less than 10 minutes, and so do not require a timetable. For routes serving multiple major destinations, several cities utilized frequencies as high as 5 minutes, such as M15 SBS in Manhattan, Lymmo in downtown Orlando, Healthline in Cleveland, 901 Metro Orange Line in LA, B×12 SBS in New York.

As for off-peak service, only two out of the 19 systems have off-peak headways longer than 20, and there are several systems having 10 or below off-peak headways, including: Franklin EmX, M15 SBS, Lymmo, 901 Metro Orange Line, and B×12 SBS.

2.3.3.1.4 Free Fee Policy

While there is no requirement for enhanced bus service to be free, at least four, or 1/5 of the 19 systems have utilized a free fee strategy for the break-in period. The free period goes as short as two days on 901Metro Orange Line in LA and as long as permanent on Lymmo in Orlando.

Table 13 Free Fee Policy of Benchmark Cases

Benchmark Cases	Free Fee Policy
New York Route 905 BUSPLUS	First 14 days free
Lynx Lymmo	Free since opening
Metro Red Line (Cedar Avenue BRT)	First week free
901 Metro Orange Line	First 2 days free

2.3.3.1.5 Fare Payment

Out of the 18 systems which collect fares, 72%, or 13, use off board fare collection. A combination of ticket vending machine and proof of payment is the most common off-board fare collection mode.

Table 14 Fare Payment of Benchmark Cases

Benchmark Cases	Fare Payment
Franklin EmX	Off board fare collection
Strip and Downtown (SDX)	Proof of payment, ticket vending machine
Los Angeles Metro Rapid	On-board fare collection, smartcard, cash(no change)
New York Route 905 BUSPLUS	Proof of payment, ticket vending machine
M15 First/Second Avenues SBS	Proof of payment, ticket vending machine
M34/M34 A SBS	Proof of payment, ticket vending machine
Lynx Lymmo	Free, no fare collection
EmX Springfield Gateway	Off board fare collection
Kansas City Metro Area Express (MAX) - Main	On board fare box
Metro Red Line (Cedar Avenue BRT)	Proof of payment, ticket vending machine
Pittsburgh West Busway	On board fare box
Pittsburgh South Busway	On board fare box
Cleveland Healthline (Euclid Corridor)	Proof of payment, ticket vending machine
Snohomish County SWIFT bus rapid transit	Proof of payment, ticket vending machine
901 Metro Orange Line	Proof of payment, ticket vending machine
B×12 Fordham Road SBS	Proof of payment, ticket vending machine
Seattle RapidRide-A Line	Proof of payment & On board fare box
South Miami-Dade Busway	On board fare box
Salt Lake 3500 South Max	Proof of payment, ticket vending machine

2.3.3.1.6 Real-time Information

The majority of systems, 16 out of 19 or 84% systems provide real-time information (Table 15). Among the 16 systems that make real-time information available to the customers, seven share the information at stations and on vehicles, three only at stations, and one only on vehicles. Six systems utilize Internet to inform passengers, with the Metro Red Line-Cedar Avenue BRT running between twin-cities also equipped with station and vehicle real-time display.

Table 15 Real-time Information of Benchmark Cases

Benchmark Cases (Open Year)	Real-time Information
Franklin EmX (2007)	Unavailable
Strip and Downtown (SDX) (2004)	Available on Internet
Los Angeles Metro Rapid (2000)	Available at stations
New York Route 905 BUSPLUS (2011)	Available at stations and on Internet
M15 First/Second Avenues SBS (2010)	Available at stations and on vehicles
M34/M34 A SBS (2008)	Available at stations and on vehicles
Lynx Lymmo (1997)	Available at stations and on vehicles
EmX Springfield Gateway (2011)	Unavailable
Kansas City Metro Area Express (MAX) – Main (2005)	Available on Internet
Metro Red Line-Cedar Avenue BRT (2013)	Available at stations, on vehicles and Internet
Pittsburgh West Busway (2000)	Available at stations and on vehicles
Pittsburgh South Busway (1977)	Available on vehicles
Cleveland Healthline-Euclid Corridor (2008)	Available at stations and on vehicles
Snohomish County SWIFT bus rapid transit (2009)	Available at stations
901 Metro Orange Line (2005)	Available on Internet
B×12 Fordham Road SBS (2008)	Available at stations and on vehicles
Seattle RapidRide-A Line (2010)	Available at stations
South Miami-Dade Busway (1997)	Unavailable
Salt Lake 3500 South Max (2008)	Available at stations and on Internet

2.3.3.1.7 Vehicles

Hybrid electric propulsion systems are dominant; 13 out of 19 systems use it (Table 16). Five systems use compressed natural gas (CNG) among other energy options. Only two systems are purely using diesel fuel which are Kansas City Metro Area Express (MAX) – Main, Salt Lake 3500 South Max.

Table 16 Vehicles of Benchmark Cases

Benchmark Cases	Vehicle
Franklin EmX	• Diesel-electric hybrid articulated buses
Strip and Downtown (SDX)	• Hybrid electric
Los Angeles Metro Rapid	• Diesel fuel, diesel hybrid technology or CNG
New York Route 905 BUSPLUS	• Hybrid electric
M15 First/Second Avenues SBS	• Hybrid electric
M34/M34 A SBS	• Hybrid electric
Lynx Lymmo	• Hybrid electric
EmX Springfield Gateway	• Hybrid electric
Kansas City Metro Area Express (MAX) – Main	• Diesel
Metro Red Line-Cedar Avenue BRT	• Hybrid electric
Pittsburgh West Busway	• Compresses natural gas (CNG)
Pittsburgh South Busway	• CNG, clean diesel
Cleveland Healthline-Euclid Corridor	• Hybrid electric
Snohomish County SWIFT bus rapid transit	• Hybrid diesel electric
901 Metro Orange Line	• CNG
B×12 Fordham Road SBS	• Hybrid electric
Seattle RapidRide-A Line	• Hybrid electric
South Miami-Dade Busway	• Diesel fuel, diesel hybrid technology or CNG
Salt Lake 3500 South Max	• Diesel

2.3.3.2 Variability

2.3.3.2.1 Context Sensitivity

The performance of most identified systems in the U.S. would not have been able to justify the operational features under the standards set forth in Table 17. For example, the Metro Red Line/Cedar Avenue BRT running between Minneapolis and Saint Paul with an average weekday ridership of 835 (August 2013) would not even be qualified as a basic bus corridor. Another example, the South Miami-Dade Busway with a two-way two-lane exclusive busway which is under the "high capacity BRT" category, should have a throughput of 15,000-45,000 persons per hour per direction (pphpd) according to the matrix, while in reality its average weekday ridership is 25,000 in 2012.

Why is there a disparity between the standards and some U.S. systems? Table 17 was developed during a workshop with the majority of the attendants are working in developing countries where there is a much larger transit rider population, so the throughput is far higher than the performance of any US system. M15 SBS (NY) has the highest average weekday ridership among all the identified U.S. cases and runs in one of the densest urban area in the U.S. - Manhattan, but the average weekday ridership of 57,000 (2012) is barely comparable to "high capacity BRT" in developing countries with a throughput of 15,000-45,000 pphpd. Therefore, the table reminds users to "note that variations apply and there is a need to design according to the local context."

Table 17 Types of Bus-Based Transit According to Transport Demand Needs and Urban Environment (Muñoz and Hidalgo 2013)

Types of bus-based transit according to transport demand needs and urban environment.

Type	Main Features	Throughput/performance	Application
Basic bus corridor	Median or curbside lanes, on board payment, conventional buses	500—5000 pphpd 12—15 km/h	Low density corridors, suburbs
Bus of high level of service BHLS	Infrastructure, technology and advanced vehicles for enhanced service provision	500—2500 + pphpd 15—35 km/h	Small urban areas, historic downtown, suburbs
Medium BRT	Single median lanes, off board payment, information technologies	5000—15,000 pphpd 18—23 km/h	Medium density corridors, suburb/center connections
High capacity BRT	Dual median lanes physically separated, large stations with prepayment, large buses, information technologies, combined services	15,000—45,000 pphpd 20—40 km/h	High demand, dense, mixed use corridors, central city

Source: Elaborated by the authors based on inputs from workshop participants. Note that variations apply and there is a need to design according to the local context.

In the same light, as the third largest country in the world, urban form, population density, and transit rider base within the US vary greatly from one area to another, so each system should be designed in a way to best meet transit need, court local demand, and exploit transit potential. Context sensitivity is something that all system planners should keep in mind. Among the benchmark cases, there is a great variation of ROW and alignment features (Table 18), which are the most important to classify the service as discussed above.

Table 18 ROW and Alignment of Benchmark Cases

Benchmark Cases	ROW / Alignment
Franklin EmX	• 60% of the route has dedicated two-way median bus lanes or a two-way reversible bus lane
Strip and Downtown (SDX)	• 4.5 miles semi-dedicated lane sharing with other transit and right-turning vehicles; the rest 2.5 miles in mixed traffic
Los Angeles Metro Rapid	• Mixed traffic
New York Route 905 BUSPLUS	• Mixed traffic
M15 First/Second Avenues SBS	• Semi-dedicated lanes sharing with right-turn vehicles, pick up/drop off activities, access drive ways • Curbside bus lanes during 7-10AM, 2-7PM • Offset bus lanes: NB on 1st Ave, SB on 2nd Ave
M34/M34 A SBS	• Semi-dedicated busway
Lynx Lymmo	• Dedicated lanes • Busways split into two one-way pairs and aligned to the curb
EmX Springfield Gateway	• Dedicated and semi-dedicated bus lanes

Table 18 (Continued)

Benchmark Cases	ROW / Alignment
Kansas City Metro Area Express (MAX) – Main	• Exclusive bus lanes during peak hours (dedicated northbound lanes during the morning rush hour and dedicated southbound lanes during the evening rush) for about 3.5 miles between County Club Plaza and River Market; the rest 5.5 miles in mixed traffic
Metro Red Line-Cedar Avenue BRT	• 11 miles bus-only shoulder lane and will cover the rest 5 miles too
Pittsburgh West Busway	• Two lane dedicated bus-only highway
Pittsburgh South Busway	• Two lane dedicated busways through trolley ROW • Bypass traffic congestion on the Liberty Bridge and Tunnel through a joint-use bus/light rail transit tunnel
Cleveland Healthline-Euclid Corridor	• Dedicated lanes
Snohomish County SWIFT bus rapid transit	• 7 miles dedicated bus lane and 10 miles in mixed traffic
901 Metro Orange Line	• 13.45 miles dedicated busway on rail ROW; the rest 1.03 miles in mixed traffic
B×12 Fordham Road SBS	• Semi-dedicated lanes; mixed traffic
Seattle RapidRide-A Line	• HOV line
South Miami-Dade Busway	• Two-way two-lane exclusive roadway on the ROW of previous Florida East Coast Railroad line
Salt Lake 3500 South Max	• One mile center aligned dedicated lane between Constitution Boulevard and Bangerter Highway; the rest in mixed traffic

In general, dedicated lanes are rare in built-out downtown corridors, and so semi-dedicated lanes sharing with right-turn vehicles may be a good alternative. Dedicated lanes are easier to achieve in suburban-downtown, activity center-activity center, activity center-transit terminal types of corridors. It is notable that Pittsburgh South Busway uses previous trolley ROW and South Miami-Dade Busway, uses previous rail ROW.

Another point worth noting is that when a system has only limited dedicated / semi-dedicated lane segments, the segment is located in the most congested area whenever possible. While this strategy may be controversial and need political support, it tends to be very effective. For example, when Salt Lake 3500 South Max opened in 2008, it did not double the ridership of its replaced route 37 until 2010 when the center aligned dedicated lane was implemented. That one mile dedicated lane has been put into the most congested segment in the 11 miles route. A similar strategy was implied in Kansas City: In Metro Area Express (MAX) – Main route, the reversible dedicated lane during peak hours has been placed in the heaviest travelled segment.

2.3.3.2.2 Funding

Funding plays a critical role in project delivery. However, due to the limited data on funding breakdowns, this paper could not perform an extensive financial analysis but suggests such a task to be carried on in future research.

According to available data, federal funds can make up as much as 77% of capital costs, but can also as little as zero. When federal funds are unavailable, such as in the case of 901 Metro Orange Line in LA, the state match becomes essential. The State of California put in $145.8 million, or 47% of the capital costs, for LA's Orange Line.

Again, the highlight is Lymmo in Orlando, the Operation & Maintenance (O&M) of which is funded through the Downtown Development Board and Parking Division.

Table 19 Funding of Some Benchmark Cases

Benchmark Cases (Open Year)	Funding
Franklin EmX (2007)	• $19.2 million of the total $25 million capital cost is funded through Federal Transit Administration Sections 5307 and 5309
EmX Springfield Gateway (2011)	• $41.3 million capital cost including $14.8 million federal funding
Metro Red Line-Cedar Avenue BRT (2013)	• $112 million capital cost including $40.6 million federal funding
901 Metro Orange Line (2005)	• Did not use Federal Transit Administration funding • State Transportation Congestion Relief Program (TCRP): $145.5 million. • State Regional Improvement Program: $300,000. • Local Prop C Transit: $168.4 million.
Lynx Lymmo (1997)	• Operation & Maintenance is funded by the city of Orlando's Downtown Development Board and Parking Division

CHAPTER 3 THE NECESSITY AND POSSIBILITY OF ENHANCED BUS SERVICE IN ATLANTA

3.1 The Necessity of Improving Transit Service

Apart from the consideration of environmental stewardship and increasing fuel costs, the major two reasons why it is necessary to improve transit service in Metro Atlanta are:

- First, the growth of population exceeds the increase of new road capacity for cars in the current settlement patterns, and so the road mileage per person is decreasing. This means roads will become more and more congested unless the single-occupancy-vehicle (SOV) drive pattern shifts;
- Second, from a social equity point of view, there are multiple population cohort groups that rely on transit to get to work, or meet other needs. Maximizing individual mobility is an embedded part of individual freedom in the U.S. Just as the Georgia Drivers Manual refers to driving as a privilege rather than a right, so owning a car and driving should not be a requirement for everyone. From a social equity perspective, then, all people should at least have one alternative other than driving to get to life necessities such as workplace, food, healthcare, and parks.

3.1.1 Regional Population Growth

Metro Atlanta is one of the fastest growing metropolitan areas in United States. According to Census data, the four counties, Cobb, DeKalb, Fulton, and Gwinnett, have all experienced significant population growth between 2000 and 2010 (Figure 7). Gwinnett County grew as high as 37% population growth in the past decade and even in DeKalb County, the one with the lowest growth rate of the four, still grew by 4% (Figure 8).

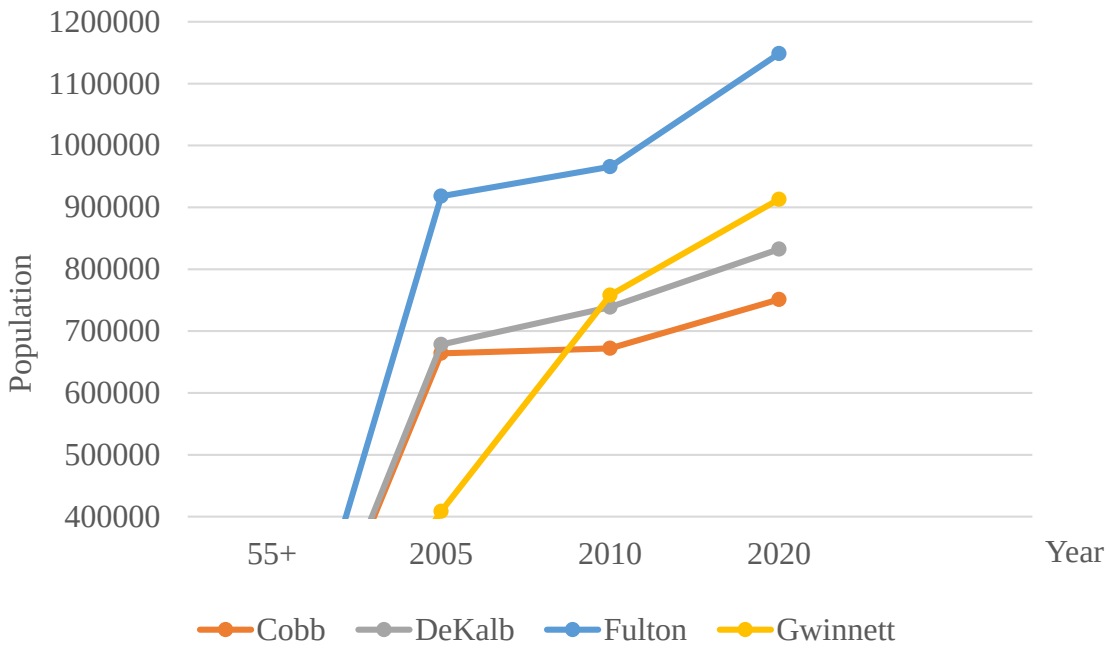

Figure 7 Population growth and forecasting from 2000 to 2040 (Data Source: US Census Bureau and ARC 2010)

Metro Atlanta's Metropolitan Planning Organization (MPO), the Atlanta Regional Commission (ARC), projected varied growth rates for the four counties over time but the overall growth trend appears certain (Figure 8). Under such a scenario, 40% to 99% population growth is expected in these four counties, which represents

- a population of 855,475 in 2040 compared to 607,751 in 2000 in Cobb,
- a population of 930,718 in 2040 compared to 665,865 in 2000 in DeKalb,
- a population of 1,338,891 in 2040 compared to 816,006 in 2000 in Fulton,
- And a population of 1,170,599 in 2040 compared to 588,448 in 2000 in Gwinnett.

While population growth and overall higher population density alone could not justify the necessity of transit improvement or confirm ridership, it is commonly recognized that denser urban area support transit better.

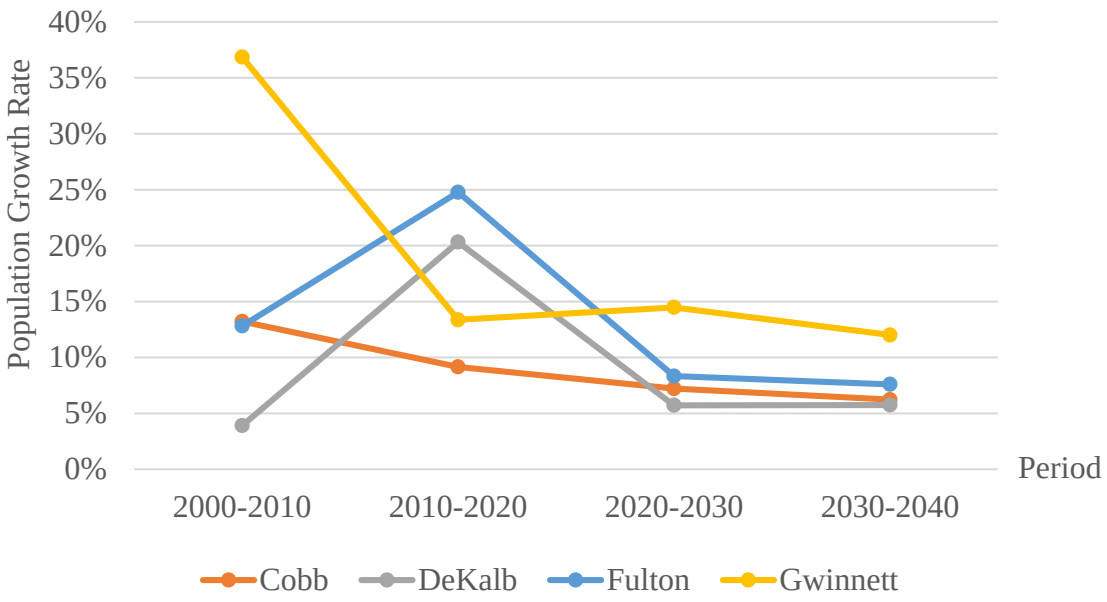

Figure 8 Population growth rate from 2000 to 2040 (Data Source: US Census Bureau and ARC 2010)

3.1.2 Transit Dependent Riders

"Transit dependent riders" refers to people who depend on transit as their major transportation mode. They are far from a single cohesive population. There are youths who haven't met the driving age requirement, seniors who don't feel up to driving by themselves any more, people who have difficulties in driving such as the disabled, and people who cannot afford a car or afford to drive. The last case is related to income directly, and there is a higher concentration of lower-income and minority in these groups than in the Caucasian population.

3.1.2.1 Low Income Population and Immigrants

In the 2009-2010 ARC transit on board survey, 85%, or 48,797 of the total 57,440 respondents live in Fulton, DeKalb, Cobb, and Gwinnett County. The result shows a concentration of low-income and immigrants population (Table 20). Except for Gwinnett County, about half of the respondents from Fulton, DeKalb, and Cobb are living in households with an annual income lower than $30,000 dollars, with the highest percentage of 60% living in Fulton. More than 20% of the respondents from the four counties don't have a car in their households. The percentage goes up to 37%, 45%, and 53% among respondents from Cobb, DeKalb, and Fulton respectively. 2.6% of respondents from Fulton County cannot speak English well, and this number goes to 3.8%, 4.5%, and 4.6% for Cobb, DeKalb, and Gwinnett accordingly.

Table 20 2009-2010 ARC Transit On Board Survey Result (Data source: 2009-2010 ARC Transit Onboard Survey)

	Fulton	**DeKalb**	**Cobb**	**Gwinnett**
Residents responded in the survey	27746	16598	2513	1940
Respondents household income below 30,000	16631	9242	1203	616
Percentage of respondents household income below 30,000	59.90%	55.70%	47.90%	31.80%
Respondents household owning no car	14606	7510	934	400
Percentage of respondents household owning no car	52.60%	45.20%	37.20%	20.60%

Table 20 (Continued)

	Fulton	DeKalb	Cobb	Gwinnett
Respondents who cannot speak English well	731	739	96	90
Percentage of respondents who cannot speak English well	2.60%	4.50%	3.80%	4.60%

3.1.2.2 Seniors

3.1.2.2.1 Senior Population Growth

Accompanying the total population growth projections, ARC also did projections on senior population change for the region until 2030. Fulton may have less elderly population by 2030 compared to 2000, but its largest base number will still put it as the county with second largest senior population of more than 120,000. Seniors in Gwinnett and DeKalb are expected to grow by 13% and 18% respectively in the 30 year horizon, while Cobb County with an 85% increase will have the largest senior population among the four, approximately 160,000.

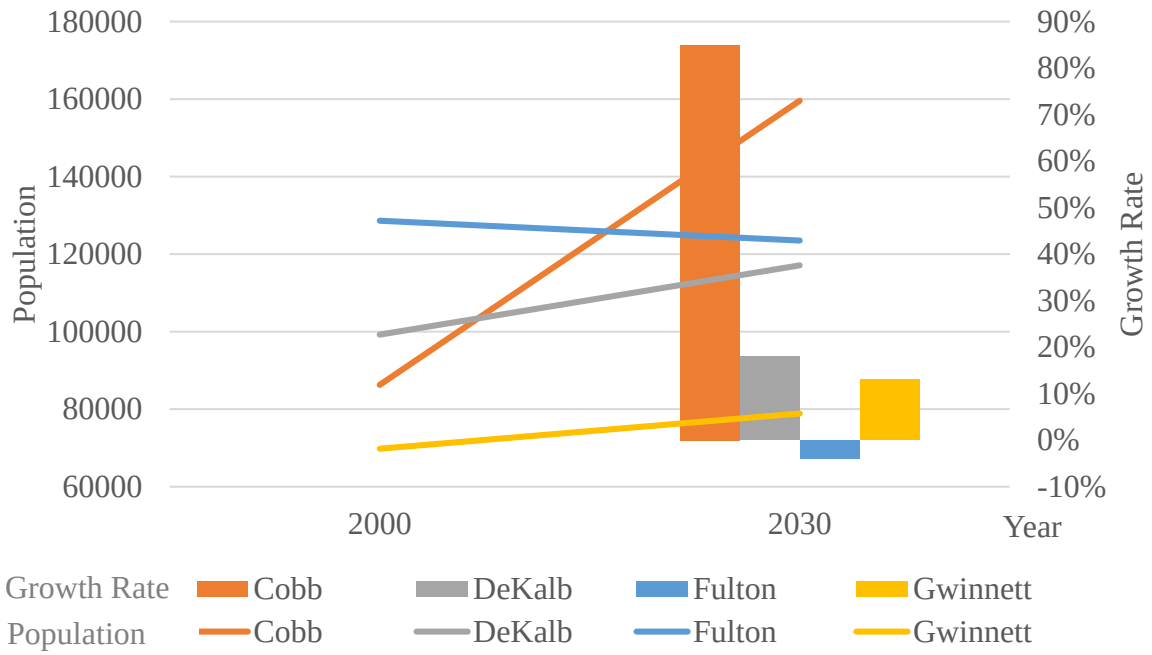

Figure 9 55+ population growth in Metro Atlanta (ARC 2007a, c, d, b)

3.1.2.2.2 Senior Population Current Status

Notably, about one third of the population over 55 are either full time or part time employed according to an ARC 2006 survey (Figure 10). The same survey also indicated more than one third of that population as doing volunteer work (Figure 11). In other words, a big portion of the 55 and over group are active in the workforce and highly socially engaged.

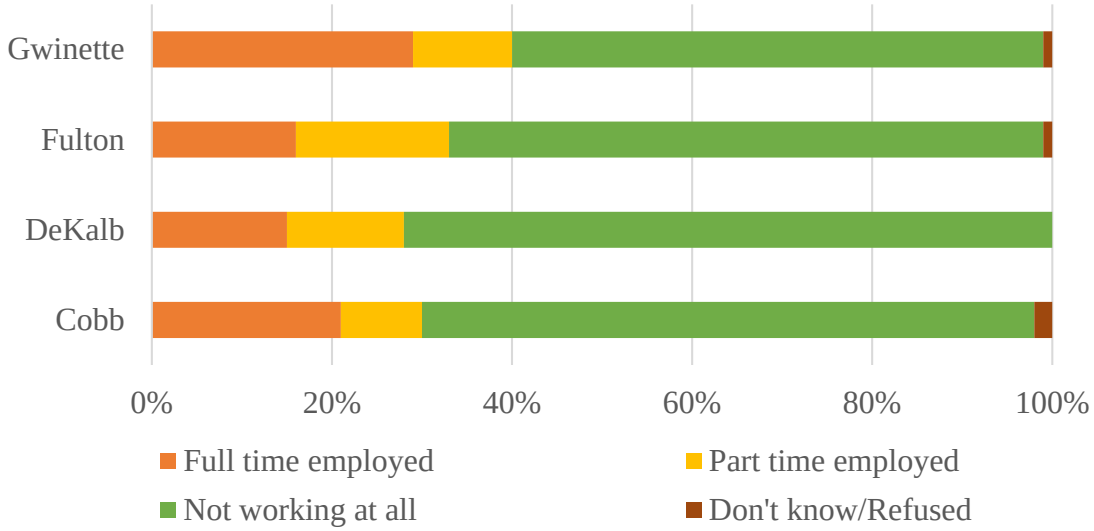

Figure 10 55+ Population Employment Status (ARC 2007a, c, d, b)

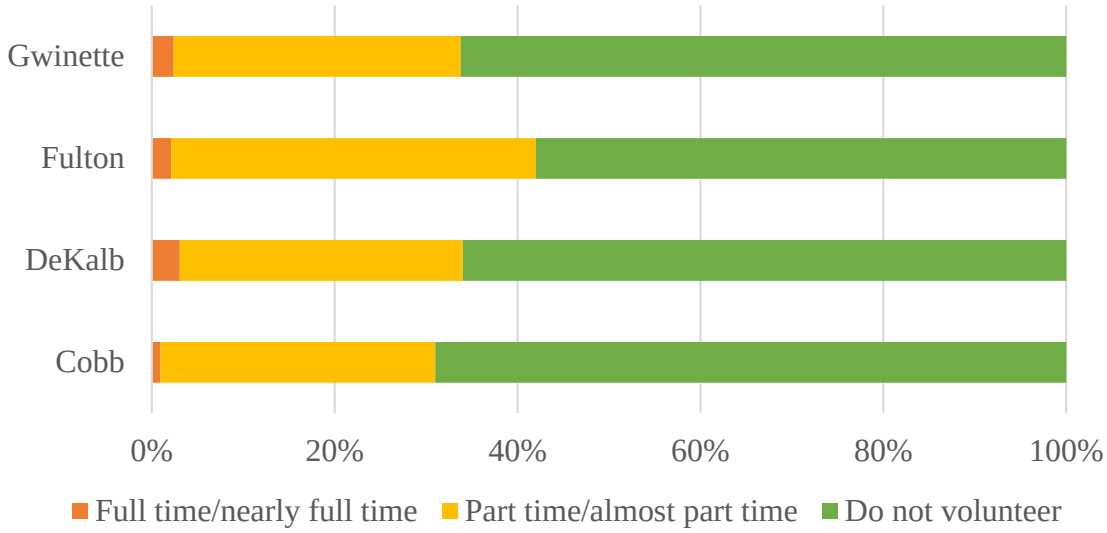

Figure 11 55+ Population Volunteer Status (ARC 2007a, c, d, b)

So how do these people get around? 80% to 90% across the counties are using their own cars with a fraction being driven by others or taking transit (Figure 12). When asked that how they are going to move around when they can no longer drive, there is an overall increase in those choosing public transportation compared to current transit use, from the

lowest increase of 50% in Cobb to the highest increase of 200% in Fulton. But the mode split of transit is still well below 20%. Over 50% are expecting to be driven around by others and about 20% don't know how they will travel around (Figure 13). If better transit service is available by the time when the elderly cannot drive by themselves, it could be expected that part of the 20% don't-know-how and even part of the 50% to-be-driven may shift to transit.

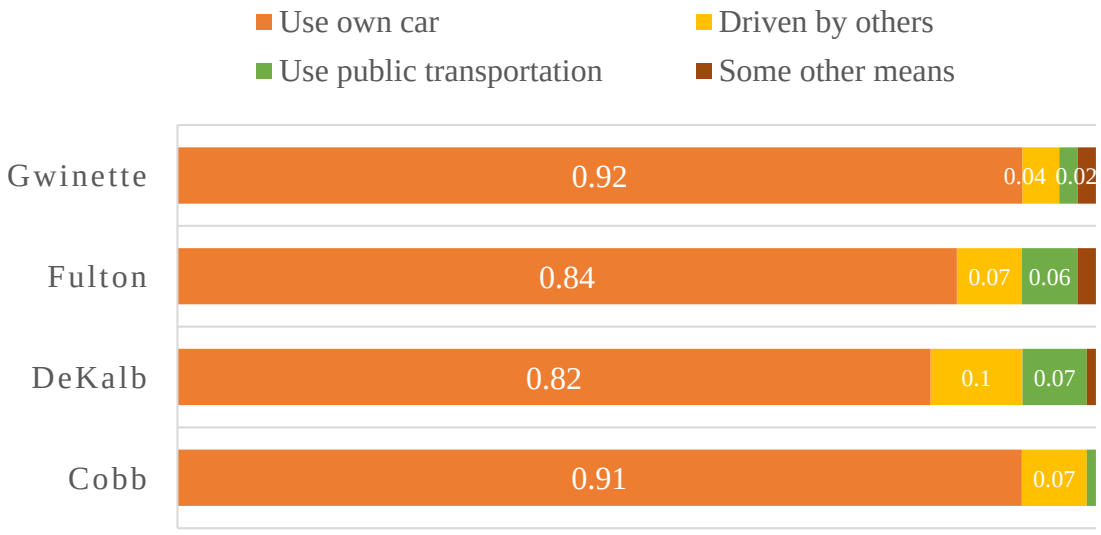

Figure 12 55+ Population Current Transportation Mode (ARC 2007a, c, d, b)

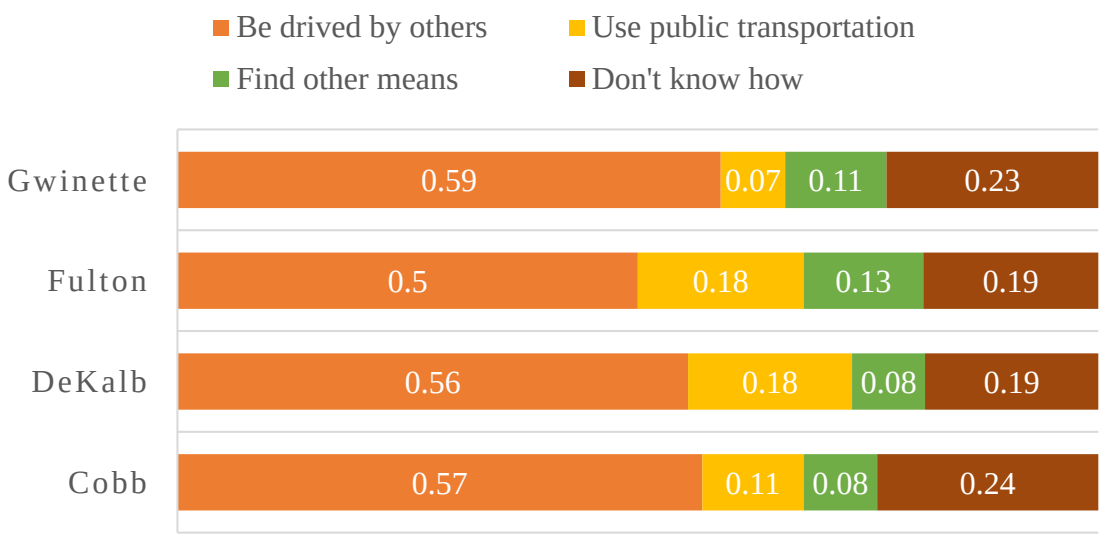

Figure 13 55+ Population Future Transportation Mode Choice

3.1.3 Choice riders

"Choice riders" refers to people who have access to other transportation modes and choose to take transit by their own free will. With climate change and sea level rise, more and more people are becoming environmentally conscious and would consider travelling collectively as a way to reduce their environmental footprint and see taking transit as a feasible alternative to driving.

There is also a boost in multi-modal population, those who choose trip mode depending on the readiness and suitability of all the available modes. This trend is particularly concentrated in Generation Y, people who were born from the early 1980s to the early 2000s (Copeland 2013). As people increasingly prefer working/relaxing on transit over sitting in traffic and the rapid development of information technology and social media, this trend is more than likely to continue.

3.1.4 Occasional riders

"Occasional riders" refers to people who take transit only for specific trip purposes such as trips to the airport or only under specific situations that they cannot or should not drive such as being drunk or sleep-deprived.

3.2 Possibility of Improving Bus Transit Service

In a recent public survey conducted in the 10-county (Cherokee, Clayton, Cobb, DeKalb, Douglas, Fayette, Fulton, Gwinnett, Henry and Rockdale counties) Atlanta region, over 71% of respondents indicated that improving public transportation is "very important" for the region's future (Saporta 2013).

Should the region pursue rail, streetcar, bus, or a combination of them? This appear to be more of a political question rather than a technical one, especially given that regarding performance, streetcar is very close to bus except having tracks on the road, in which streetcars incorporates higher capital and O&M cost basically. Therefore, this paper does not compare the differences between the modes and instead focuses on the possibilities for implementing enhanced bus service.

3.2.1 Market Potential

ARC completed a regional household travel survey in 2011 (ARC 2011). After collecting trip data through travel diaries from 10278 households, ARC did two GPS add-on sample group surveys, including one on 436 households that reported daily use of public transit in their travel diary. Out of the 436 households provided with a wearable GPS device to record their travel data, 414 households completed the GPS survey.

14366 unlinked trip segments were recorded and a majority, 70.37%, were made by automobile. About 1% of all trips were made by MARTA train or local bus and interestingly the 1% split between the two modes split quite evenly (Figure 14).

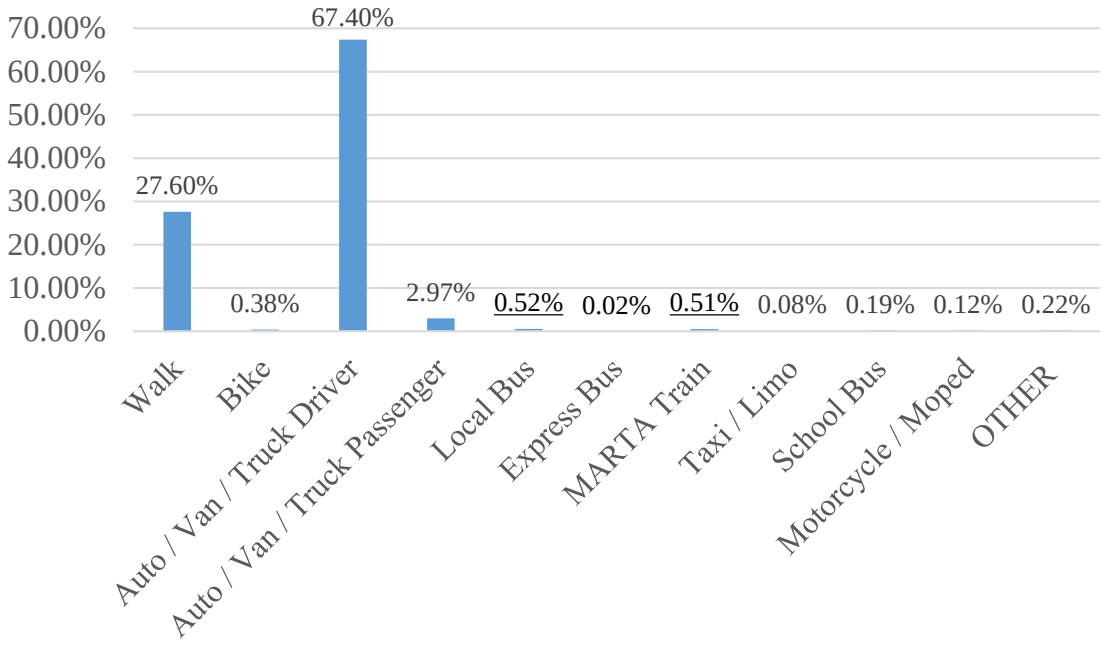

Figure 14 Trip Percentage by Travel Mode in 2011 ARC Survey (NuStats and GeoStats 2011)

Based on the recorded origins and destinations, trips are categorized into Home Based Work/School trips (HBW/S) with an origin of home and a destination of either workplace or school, Home Based Other trips (HBO) with an origin of home and a destination of anywhere other than workplace or school, and Non Home Based trips (NHB) with an origin of anywhere other than home. The mode percentage by trip purpose (Table 21) shows that none of the HBW/S trips were made on local bus, express bus, or MARTA. As for HBO trips, 0.45% were made on local bus but none on express bus or MARTA. The NHB trips

covered all three transit modes, but the total of trips by local bus, express bus, or MARTA, only composed 1.3% of NHB trips.

Table 21 Mode Percentage by Trip Purpose in 2011 ARC Survey (NuStats and GeoStats 2011)

	HBW/S	HBO	NHB
Walk	28.82%	25.25%	26.98%
Bike	0.31%	0.37%	0.36%
Auto / Van / Truck Driver	65.73%	70.91%	67.70%
Auto / Van / Truck Passenger	3.27%	2.82%	3.06%
Local Bus	**0.00%**	**0.45%**	**0.58%**
Express Bus	**0.00%**	**0.00%**	**0.03%**
MARTA Train	**0.00%**	**0.00%**	**0.67%**
Taxi / Limo	0.00%	0.00%	0.10%
School Bus	1.25%	0.16%	0.14%
Motorcycle / Moped	0.62%	0.04%	0.11%
OTHER	0.00%	0.00%	0.28%

According to the 14366 unlinked trips, the average travel speed of local bus is about 19 mph, two thirds of the speed of automobiles, and four fifth of MARTA train. The quickest mode is express bus, with an average speed of 45 mph, 50% quicker than automobiles. It is noticeable that there are only 3 trips made by Express Bus out of the more than ten thousand samples, so the average may not represent the average performance of express bus service. However, the 50% margin over automobiles is a positive sign that express bus service may be able to outperform cars.

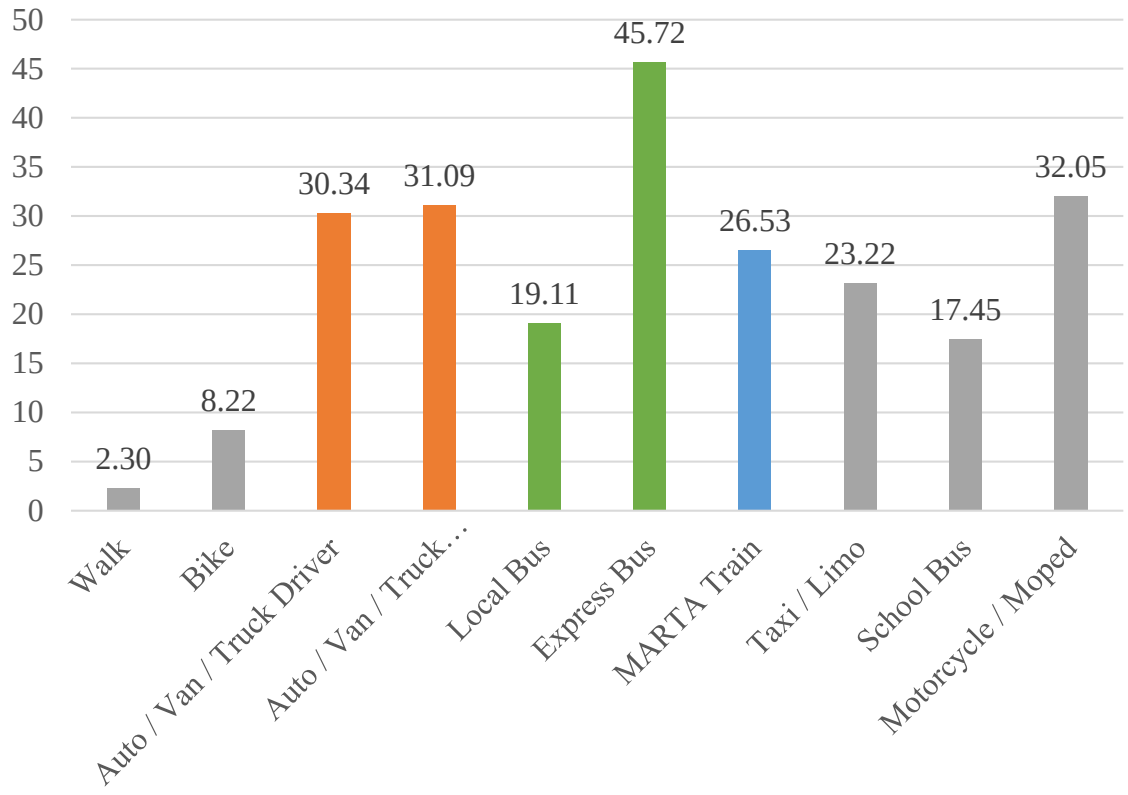

Figure 15 Average Travel Speed (MPH) by Mode in 2011 ARC Survey (NuStats and GeoStats 2011)

3.2.2 Potential Corridor Identification

3.2.2.1 Most travelled Corridors

Annual Average Daily Traffic (AADT) data are a good gauge of the daily use of a road. 2010 AADT data from GDOT were utilized to identify the most travelled corridors within the four counties of Fulton DeKalb, Cobb, and Gwinnett. As the traffic volume on interstate and expressways is much higher than that on any other arterials, and the permitted use of HOV/HOT lanes to transit vehicles is a given, interstates and expressways were taken out from the following analysis. With data points on Interstate Principal Arterials and Expressways removed, the lowest AADT number recorded is 20 vehicles per day and the

highest 83,150 vehicles per day. The 80th percentile is at 19,390 vehicles per day. The top 20th percentage data points representing the heaviest traffic counts were mapped (Figure 16).

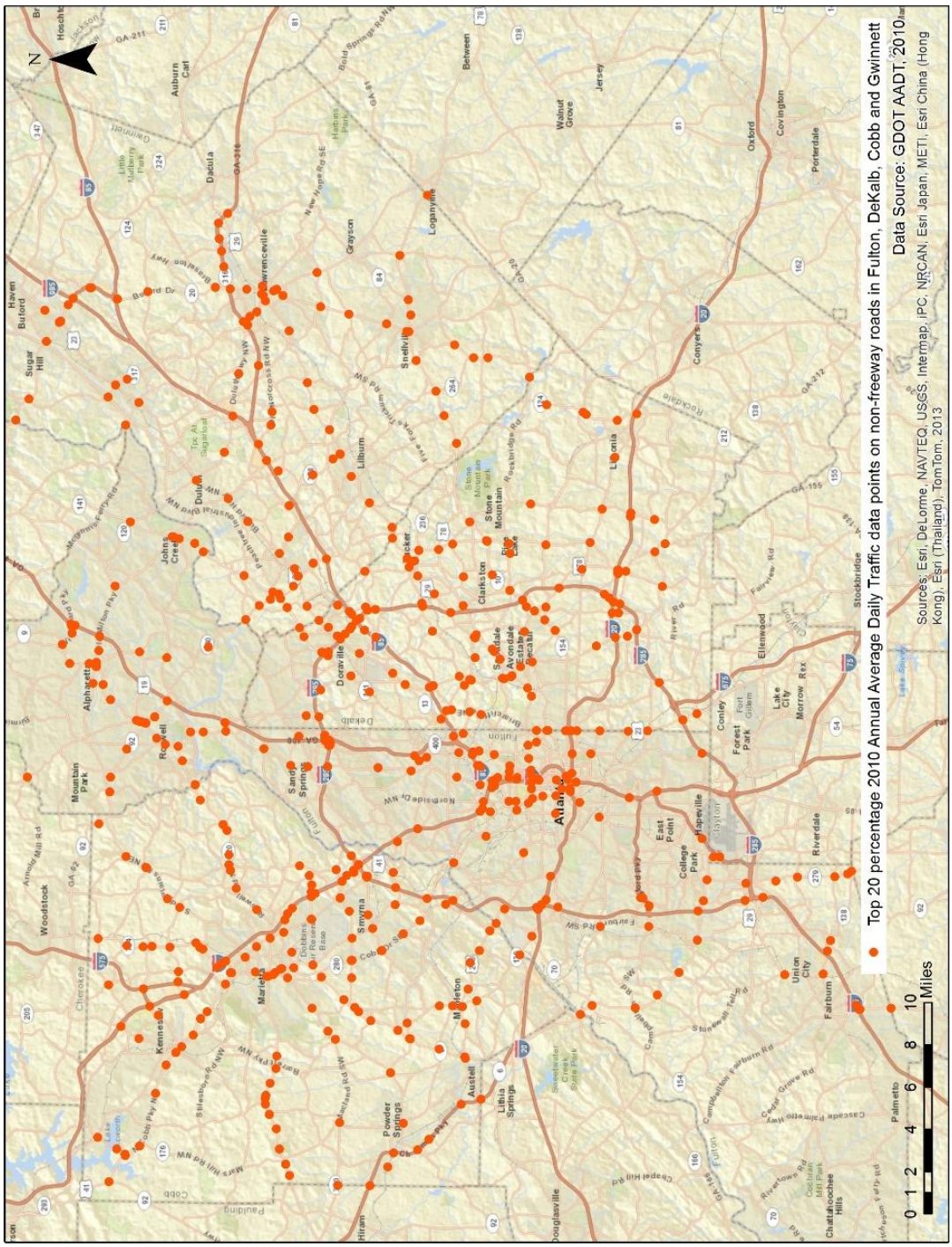

Figure 16 Top 20 Percentage of 2010 AADT data points in four-county area

By linking the plotted AADT data points, corridors shown in Figure 17 turned out to be the most heavily travelled except interstate highways and access-controlled freeways.

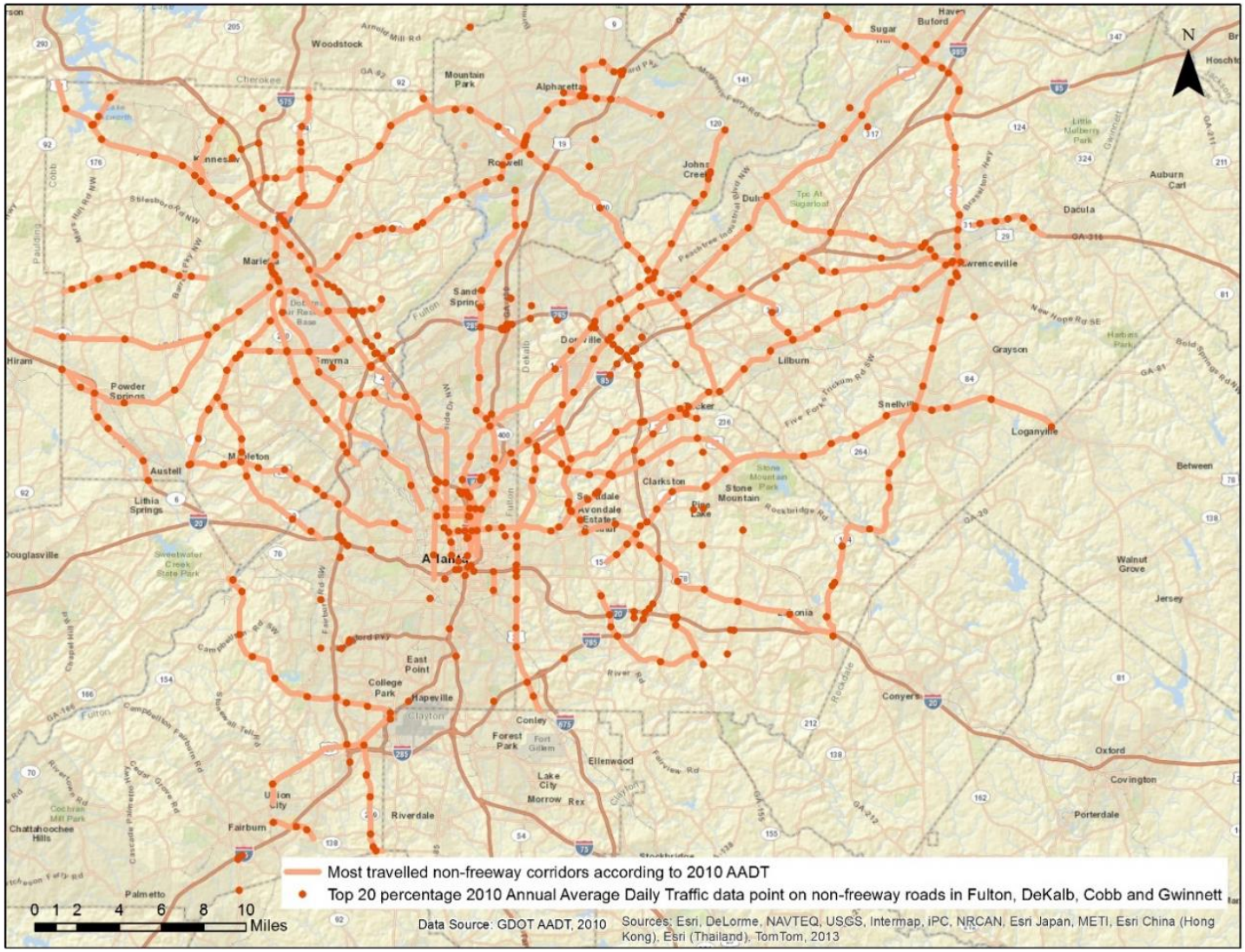

Figure 17 Most Travelled Non-Controlled-Access Corridors According to 2010 AADT

By examining the relationship with activity centers, corridors were refined and further connected (Figure 18).

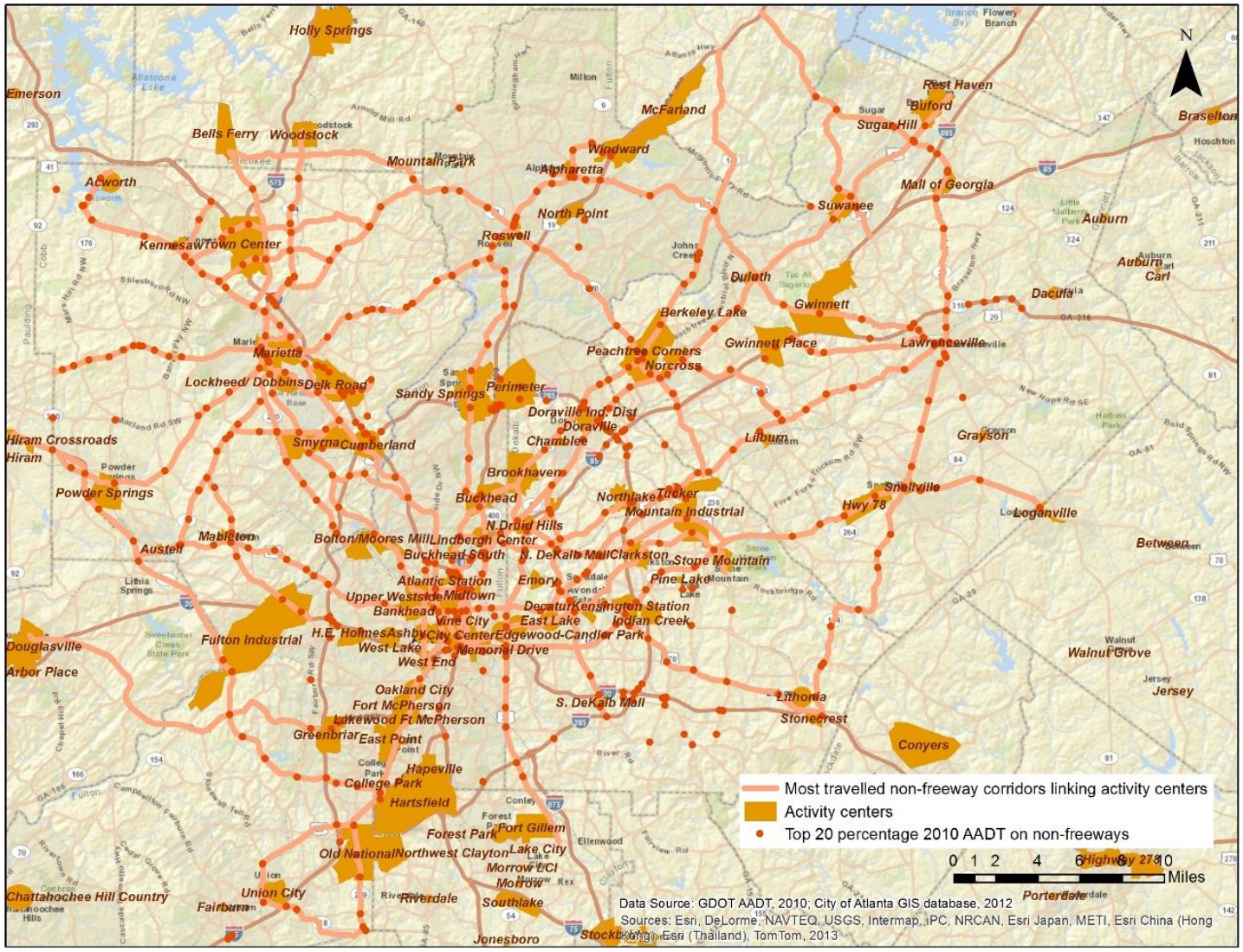

Figure 18 Most Travelled Corridors Linking Activity Centers

3.2.2.2 Population Density and Minority Percentage

Population density and minority population percentage are taken into account for identifying potential BRT and BHLS corridors. Population density represents the base pool of customers for the transit market, while the consideration of minority population percentage establishes a social equity basis. Minority populations are overall financially worse off than white populations, and they have a higher percentage of immigrants who tend to be transit dependent riders.

After assembling road segments by road name, 155 roads are identified in the selected corridors. The 155 roads passed through 853 census block groups (Figure 19).

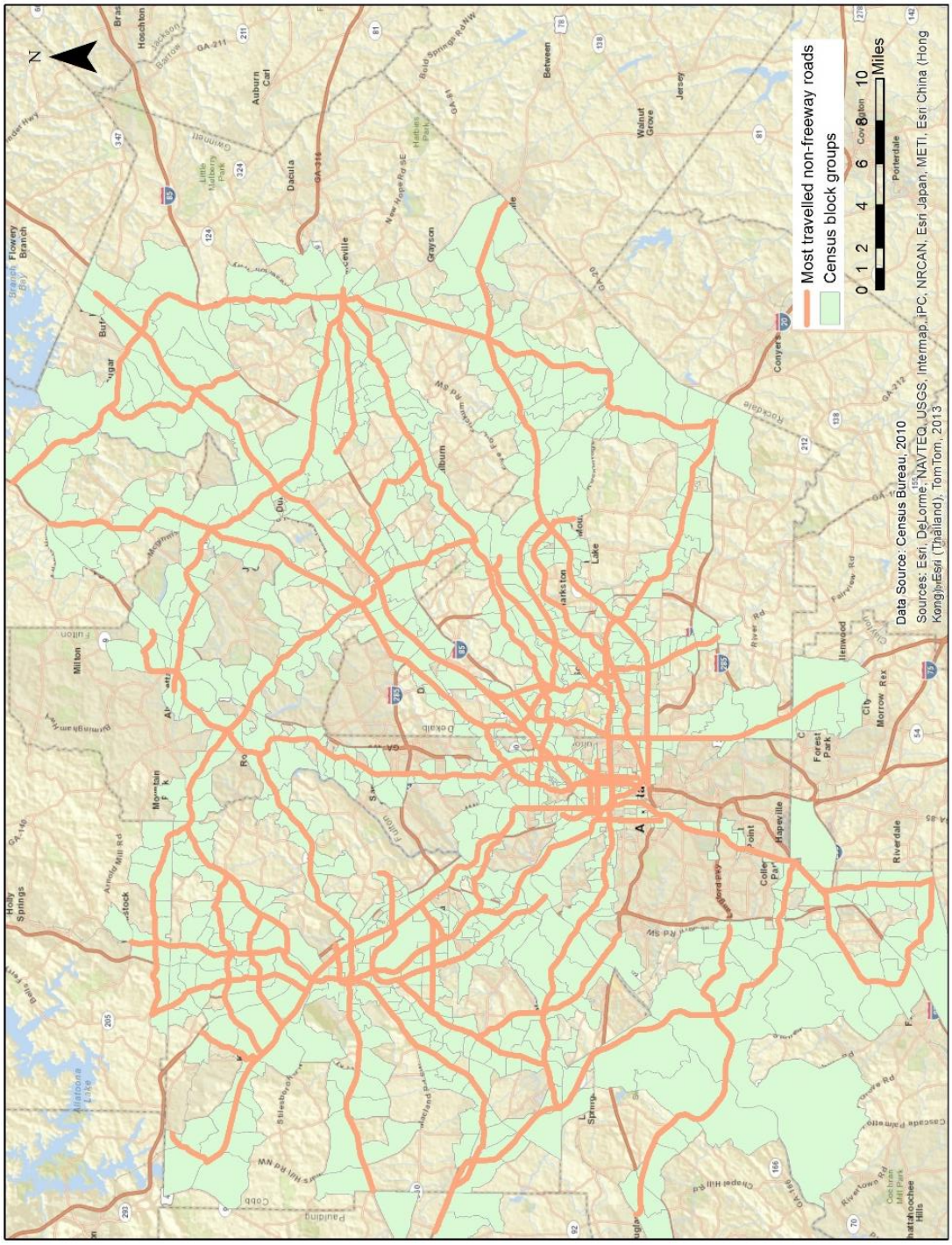

Figure 19 Census Block Groups Traversed by Most Travelled Corridors

As for population density of the 853 census block groups, the lowest 20% have zero to two persons per acre while the highest 20% vary from nine to 83 persons per acre. The majority 60% have three to eight persons per acre (Figure 20).

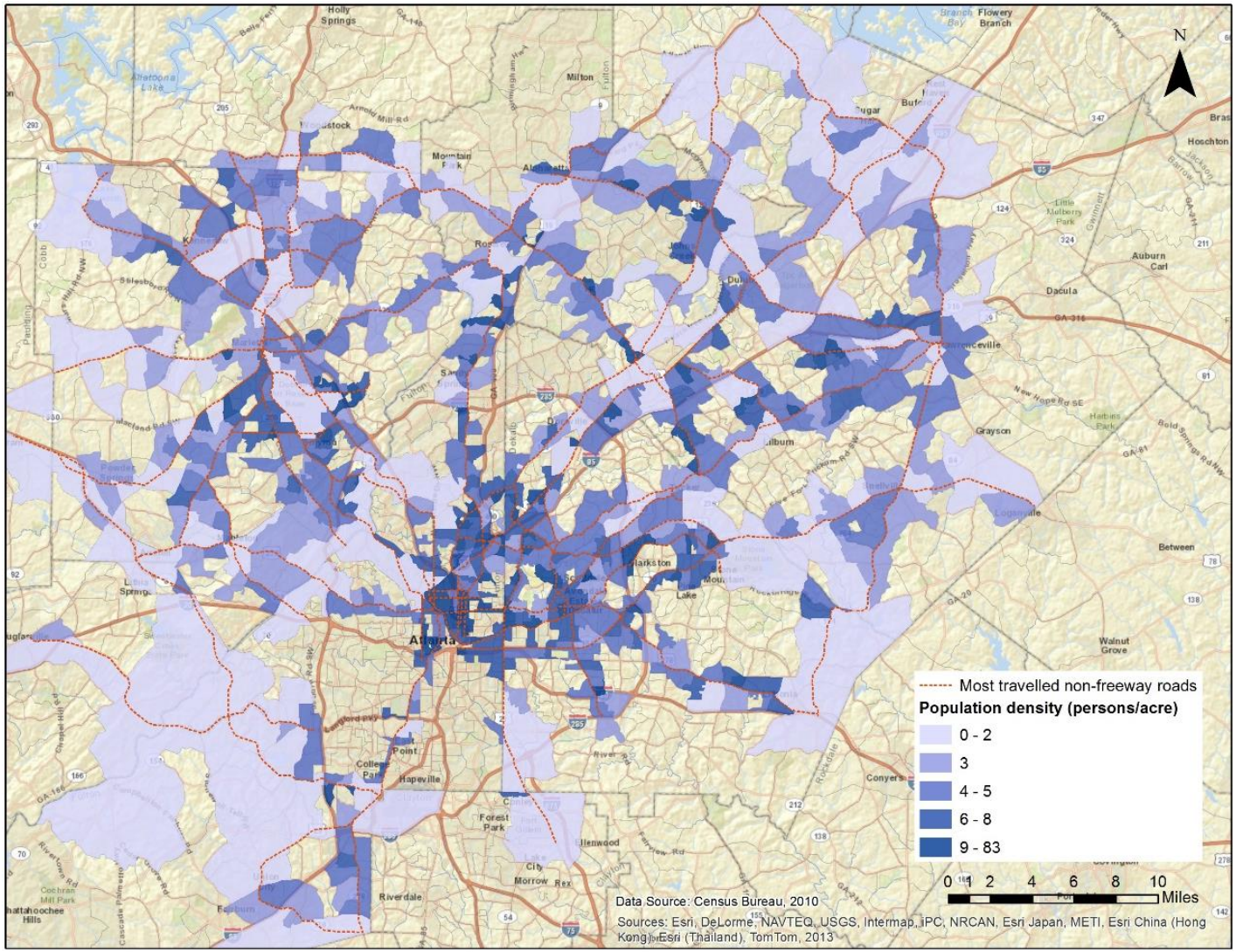

Figure 20 Population Density of the Census Block Groups Traversed by Most Travelled Corridors

Of the 853 block groups, 394 (46.2%) have a larger minority population than white population. Minority population percentage is generally higher in the south part and lower in the north part. There are also high concentrations of minority population along Interstate 85 and in the area between Interstate 75 and Interstate 20 (Figure 21).

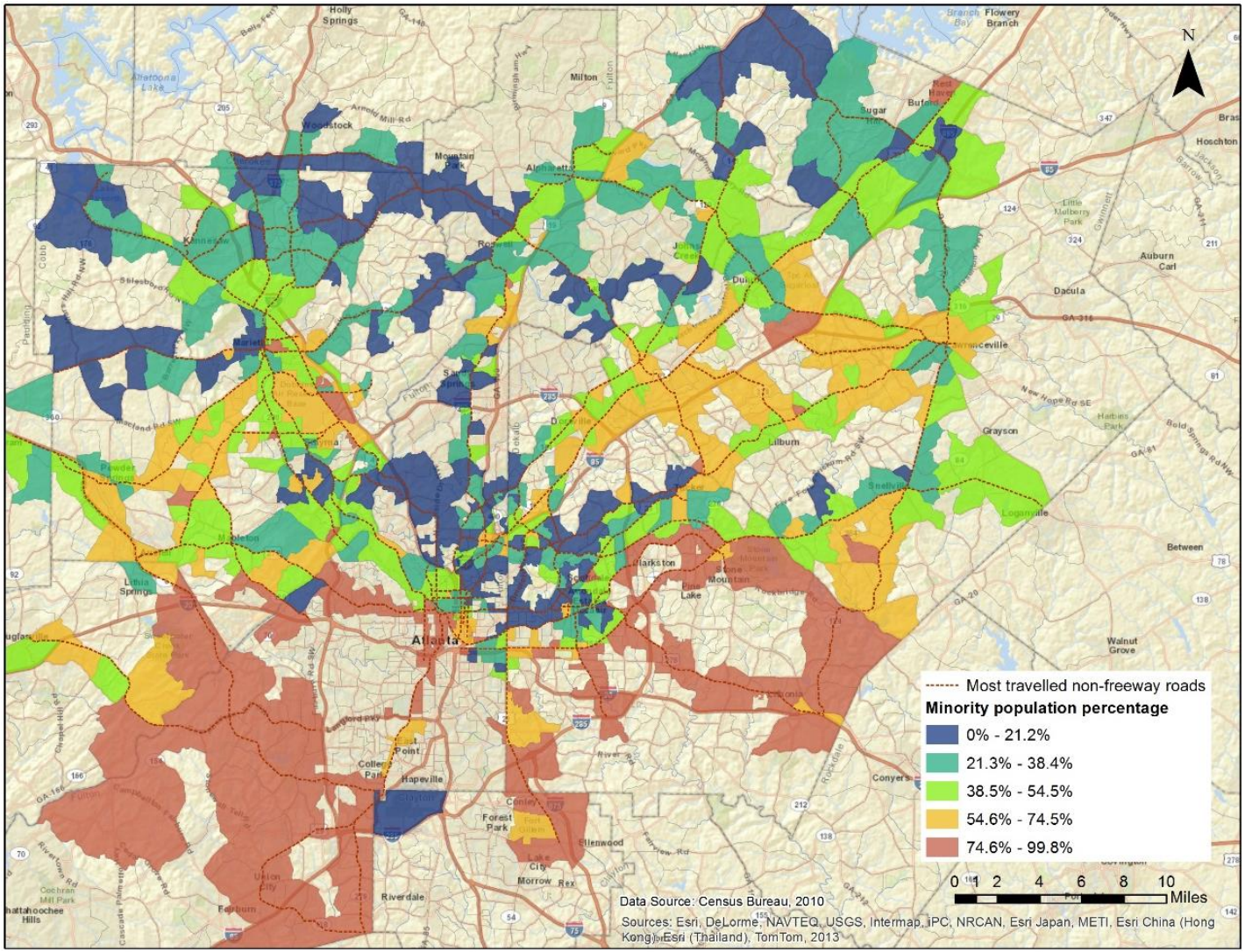

Figure 21 Minority Population Percentage of the Census Block Groups Traversed by Most Travelled Corridors

Figure 22 shows a combined view of the minority population percentage and relative population density of the census block groups traversed by the identified most travelled non-freeway corridors.

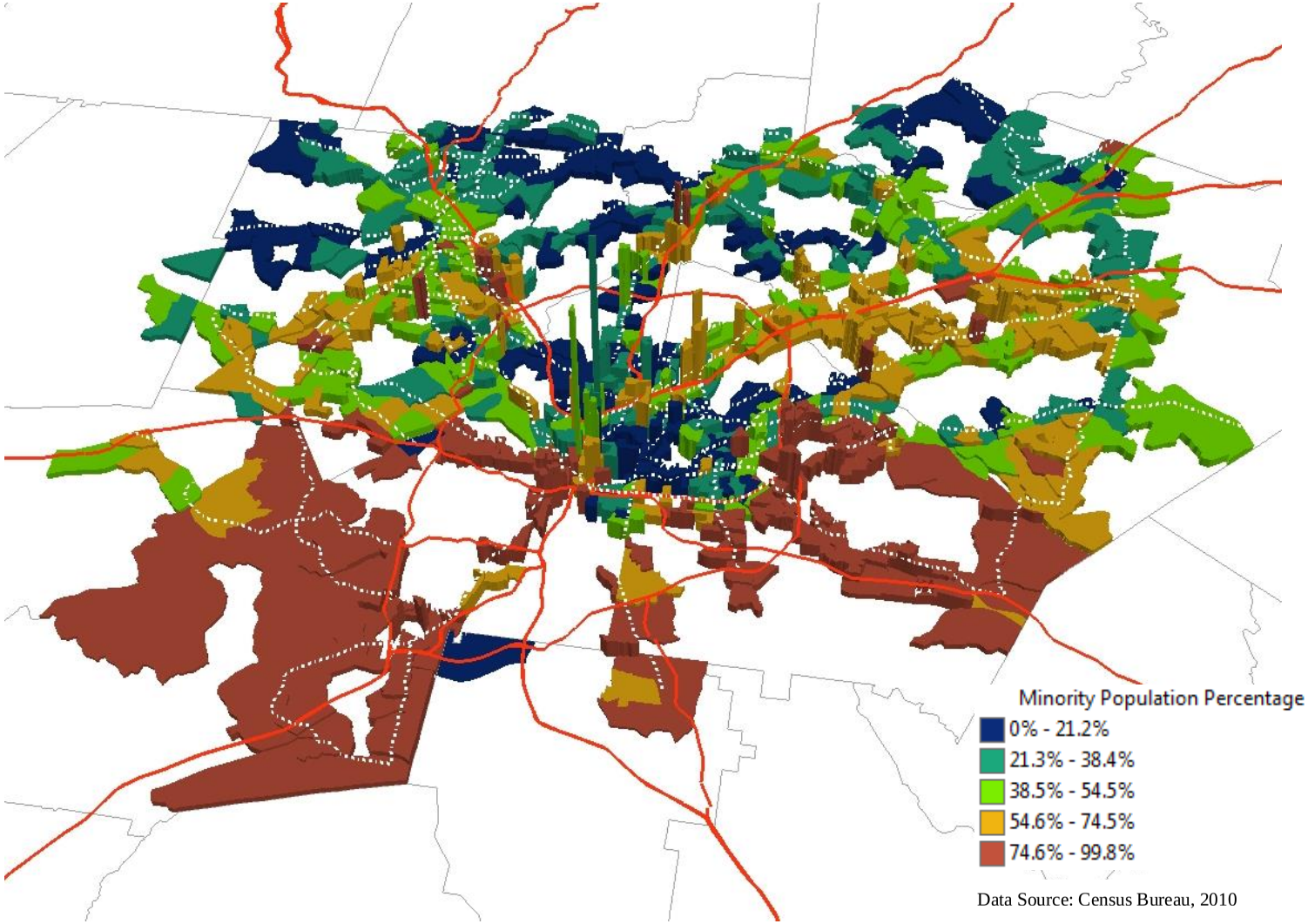

Figure 22 Minority Population Percentage and Relative Population Density of the Census Block Groups Traversed By the Identified Most Travelled Non-Freeway Corridors

Minority population density is calculated by multiplying the population density and minority population percentage (Figure 23).

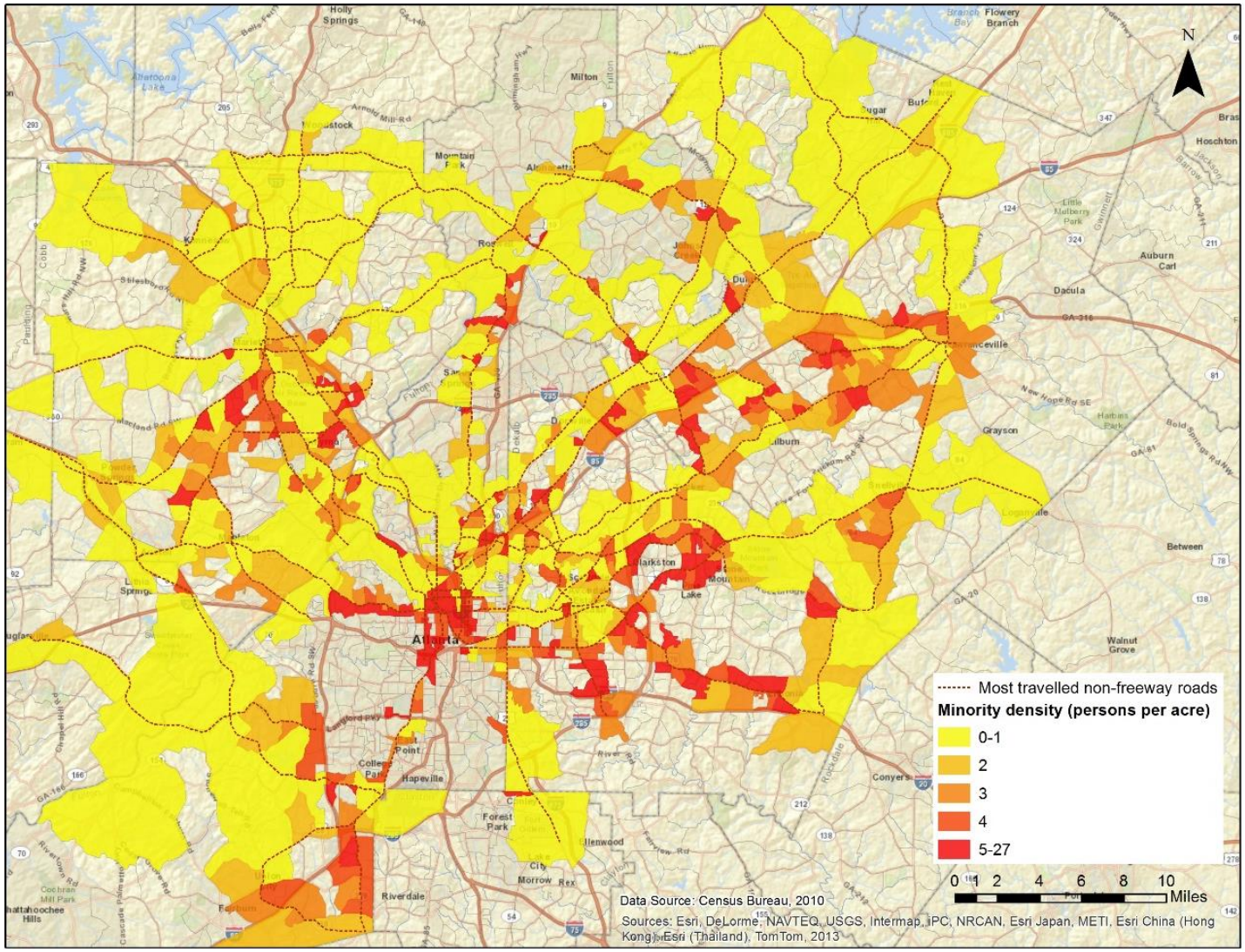

Figure 23 Minority Density of the Census Block Groups Traversed by Most Travelled Corridors

In ArcGIS, the layer of most travelled roads and the layer of census block groups were overlaid. The attributes at the block group level, including population density and minority density, were attached to each segment of the road. The length of each segment was also calculated.

To get an average score of minority density along each road, the minority density was multiplied by segment length at the road segment level. Then the dissolve function was used to summarize the maximum population density of the block groups traversed by a road and to calculate the sum of "minority density by segment length" of each road, as well as the total length of each road. Then the average minority density of the area traversed by each road was calculated by dividing the sum of "minority density by segment length" by the total length of each road.

The reason the study chose maximum population density along each road rather than the average population density is that high concentrations of population represent the gravity of trip generation or attraction or both. Even if just a fraction of the road is located in an area of high population density, the high travel demand of road is indicative.

The approximate average minority density along the road was used to determine whether a road is a corridor or part of a corridor with an ethnically more diverse population, which often relates to a larger base of transit dependent riders.

To rate the suitability of a road as (part of) a BRT or BHLS corridor, a rating system was developed (Table 22).

Table 22 Suitability Rating System for Enhanced Bus Service

Maximum population density (persons per acre)	Average minority density (persons per acre)	Suitability Score	Suitability Interpretation
14-83 (top 20 percentile)	5-13 (top 20 percentile)	5	Highest density and greater diversity
	0-4 (lower 80 percentile)	4	Highest density and less diversity
8-13 (upper 20-40 percentile)	5-13 (top 20 percentile)	3	High density and greater diversity
	0-4 (lower 80 percentile)	2	High density and less diversity
5-7 (lower 60 percentile)	any	1	Modest density
1-3 (lower 60 percentile)	any	0	Low density

Using the rating system, roads were assigned suitability scores (Figure 24). The higher the score, the more suitable the road for BRT or BHLS according to its current population characteristics. Note that while the road with lower suitability score may not justify BRT or BHLS under its current condition, if combined with zoning to promote land use of higher density, it would then qualify for a BRT/BHLS project.

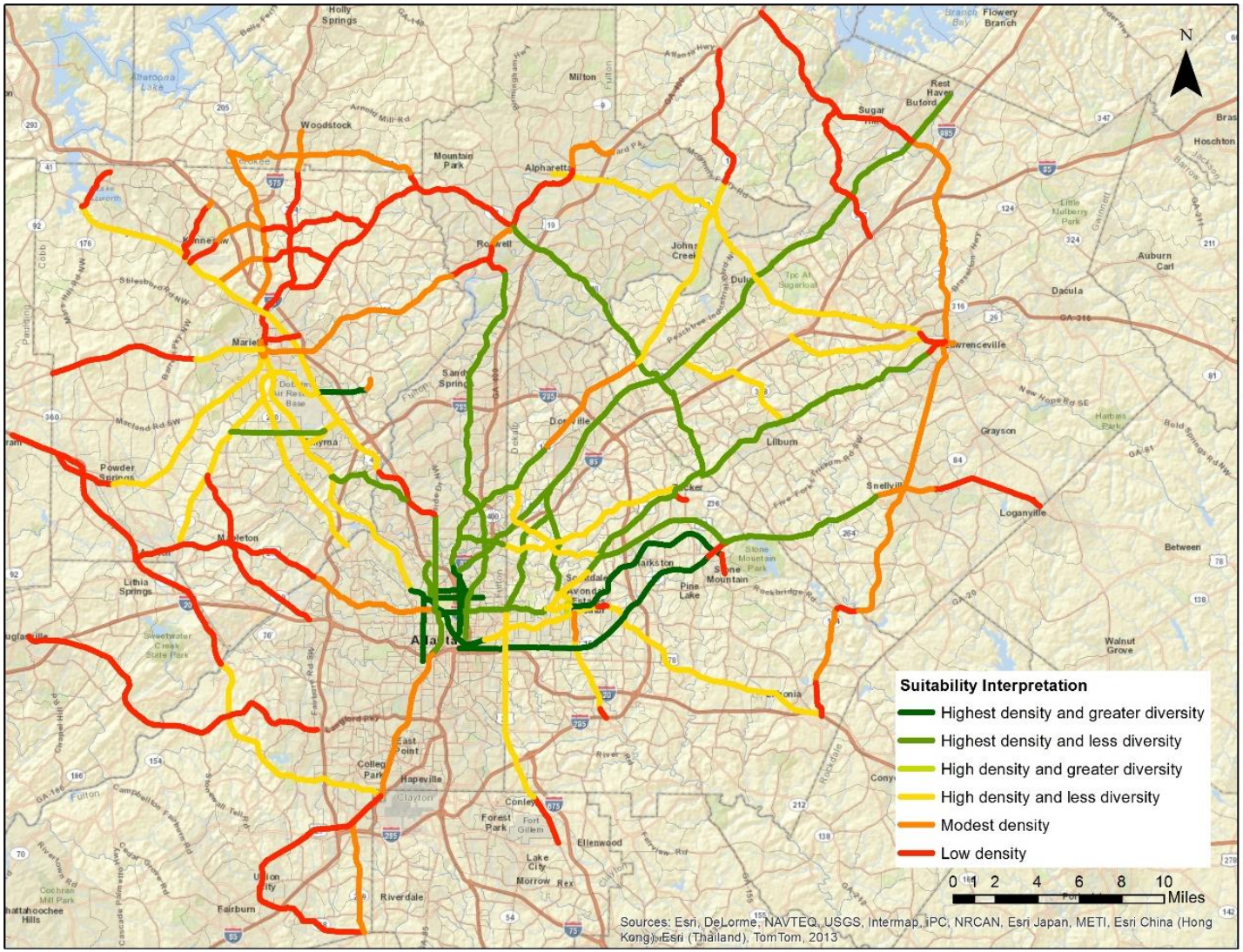

Figure 24 Enhanced Transit Service Suitability of Most Travelled Roads

Taking activity centers into consideration, the high scored roads and interstate highways were linked to form continuous corridors (Figure 25).

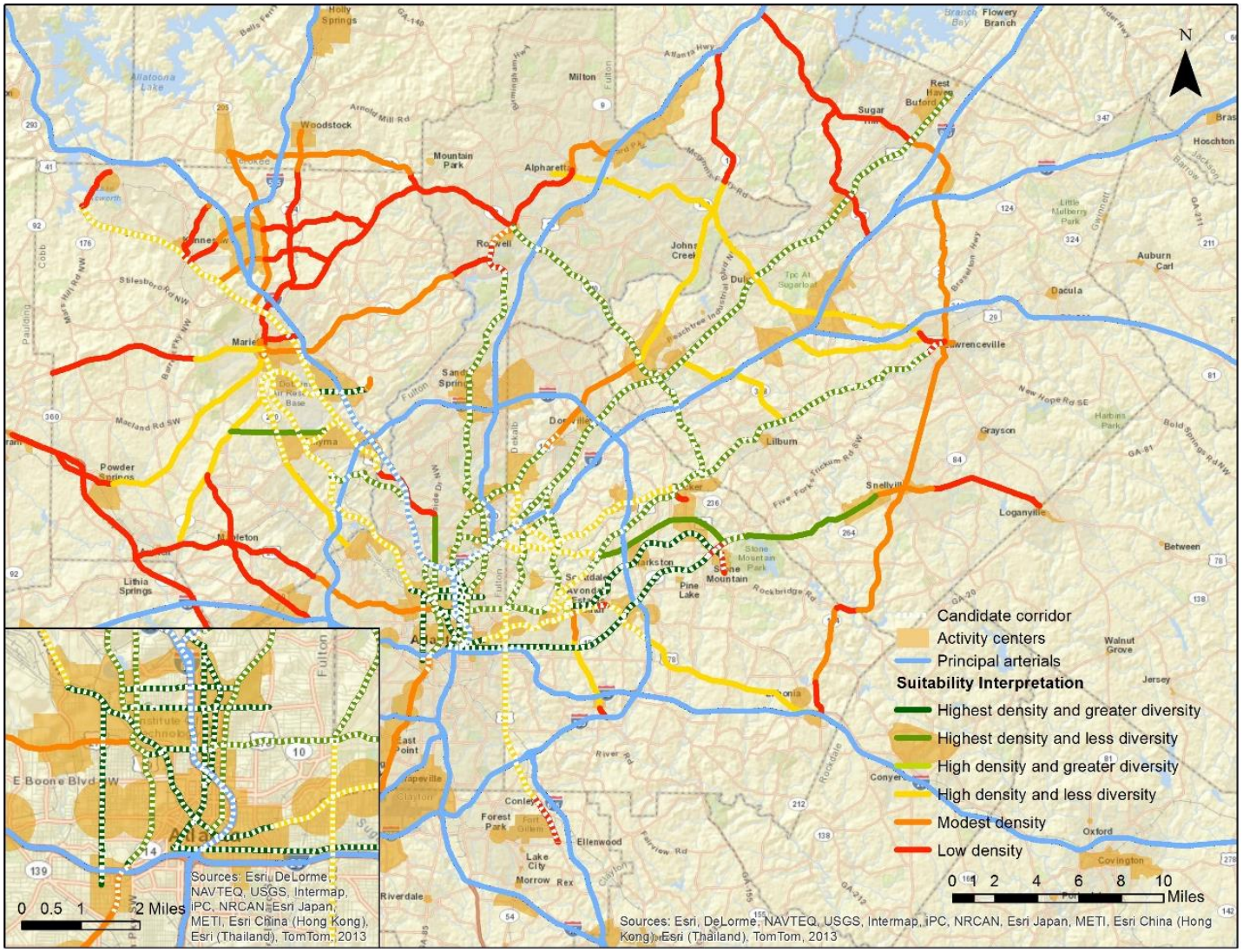

Figure 25 Linking the High Scored Roads and Interstate Highways to Form Continuous Corridors

Figure 26 highlights the resulting candidate corridors.

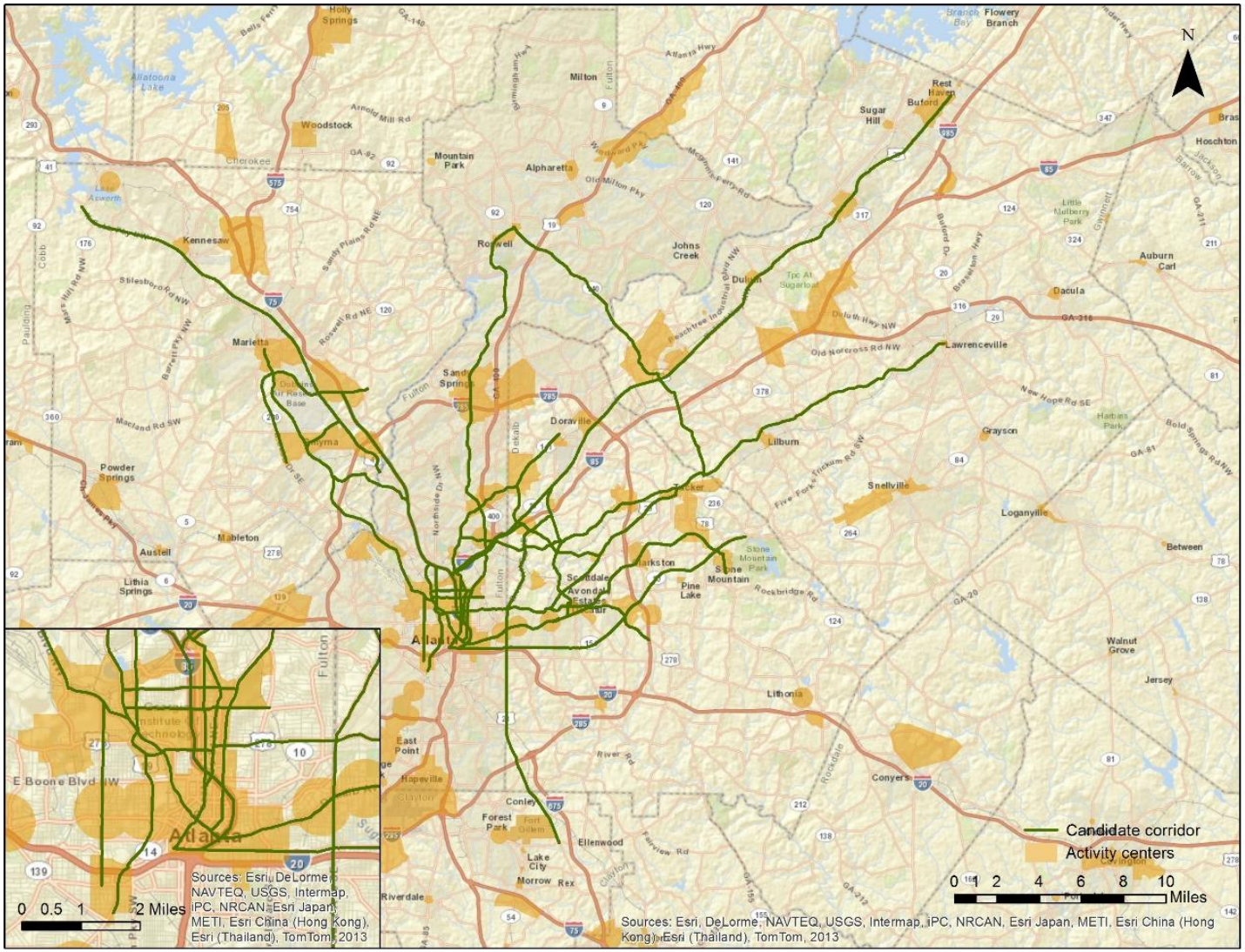

Figure 26 Candidate Corridors

3.2.2.3 Comparison with existing transit services

Comparing with existing MARTA, GCT, CCT, and Xpress bus service (updated to 2012), it turns out that some segments of the BRT/BHLS candidate corridors are not covered by any existing bus service (Figure 27).

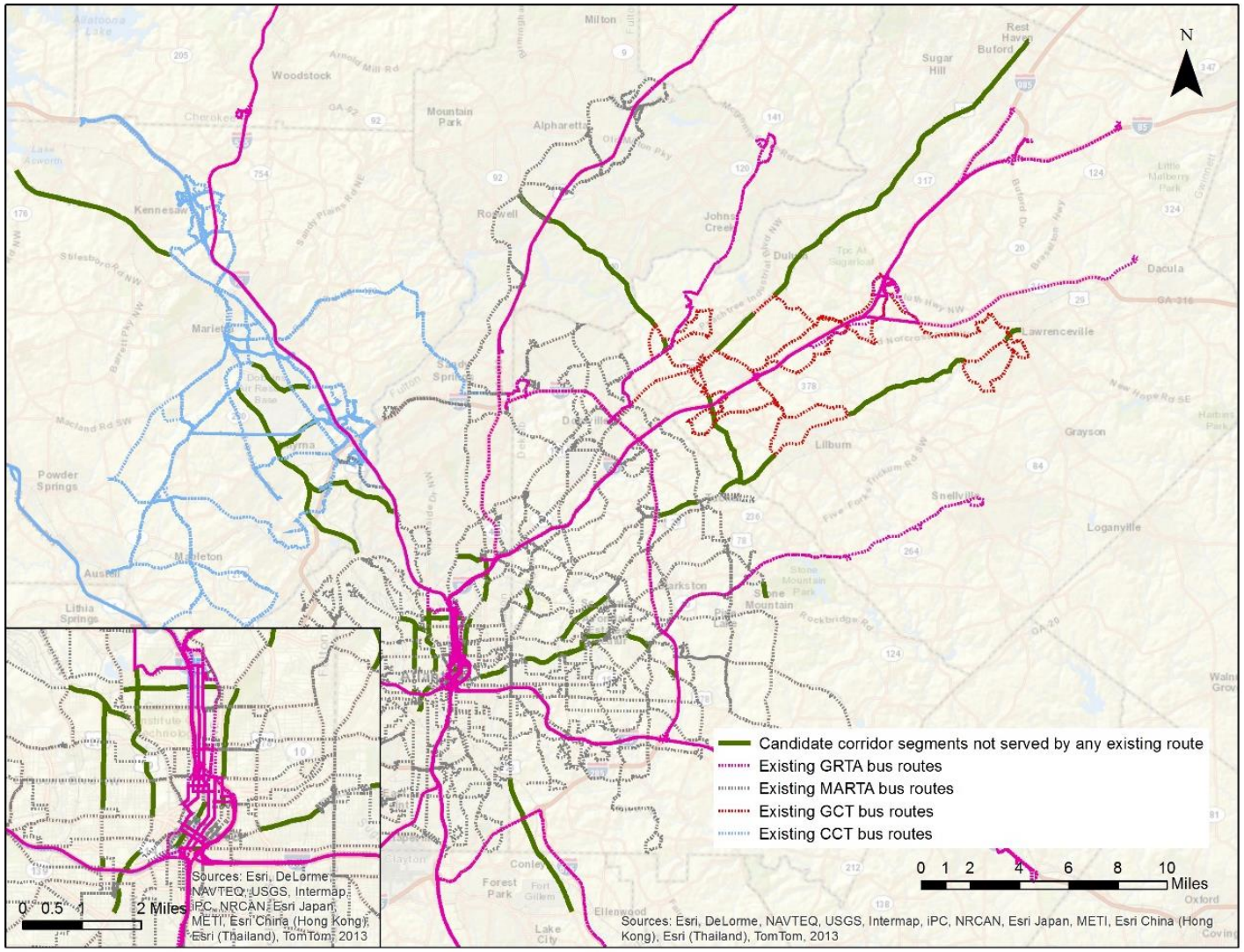

Figure 27 Candidate Corridor Segments Not Served by Any Existing Routes

The research further refines the candidate pool by considering land use intensity, adjacent road patterns, and public facilities. Thus, using Google earth images (updated to 2013), segments with less developed land, connecting to predominant cul-de-sac road networks and lacking public facilities such as libraries and parks, were taken out from the candidate pool (Figure 28). Conversely, segments with more developed land, connecting to predominant grid road network, and more public facilities, were kept in the candidate pool even if they are not served by any existing service (Figure 29).

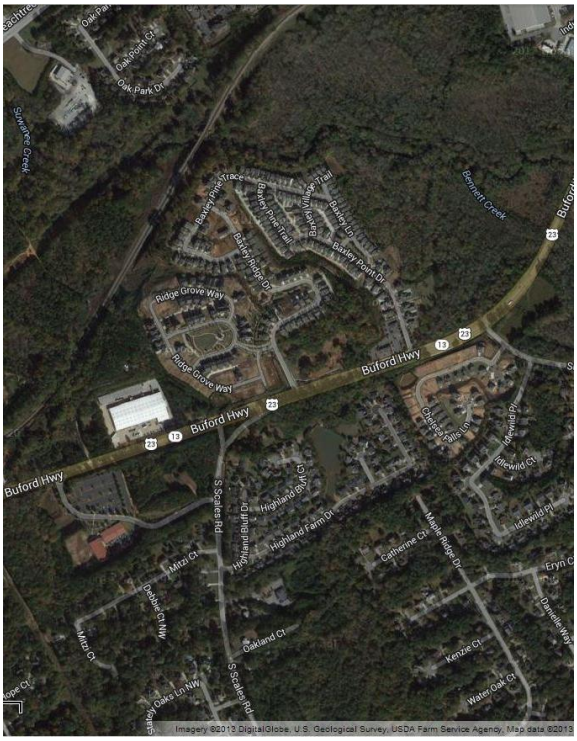

Figure 28 Example of segments to take out (Image source: Google map, 2013)

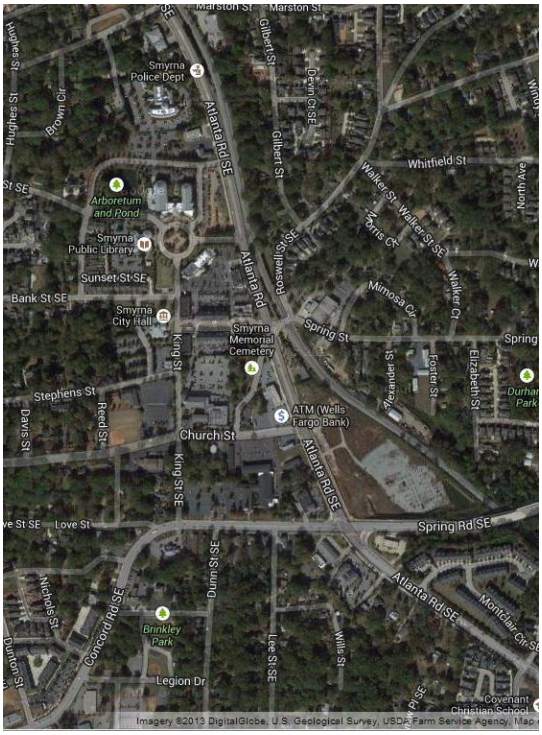

Figure 29 example of segments to keep (Image source: Google map, 2013)

Of the 238 miles BRT/ BHLS candidate corridor lengths, 77 % or 184 miles are served by existing bus routes. However, none of the candidate corridors is covered by a continuous route (Figure 30), while most benchmark cases in other cities have used relatively simple routes.

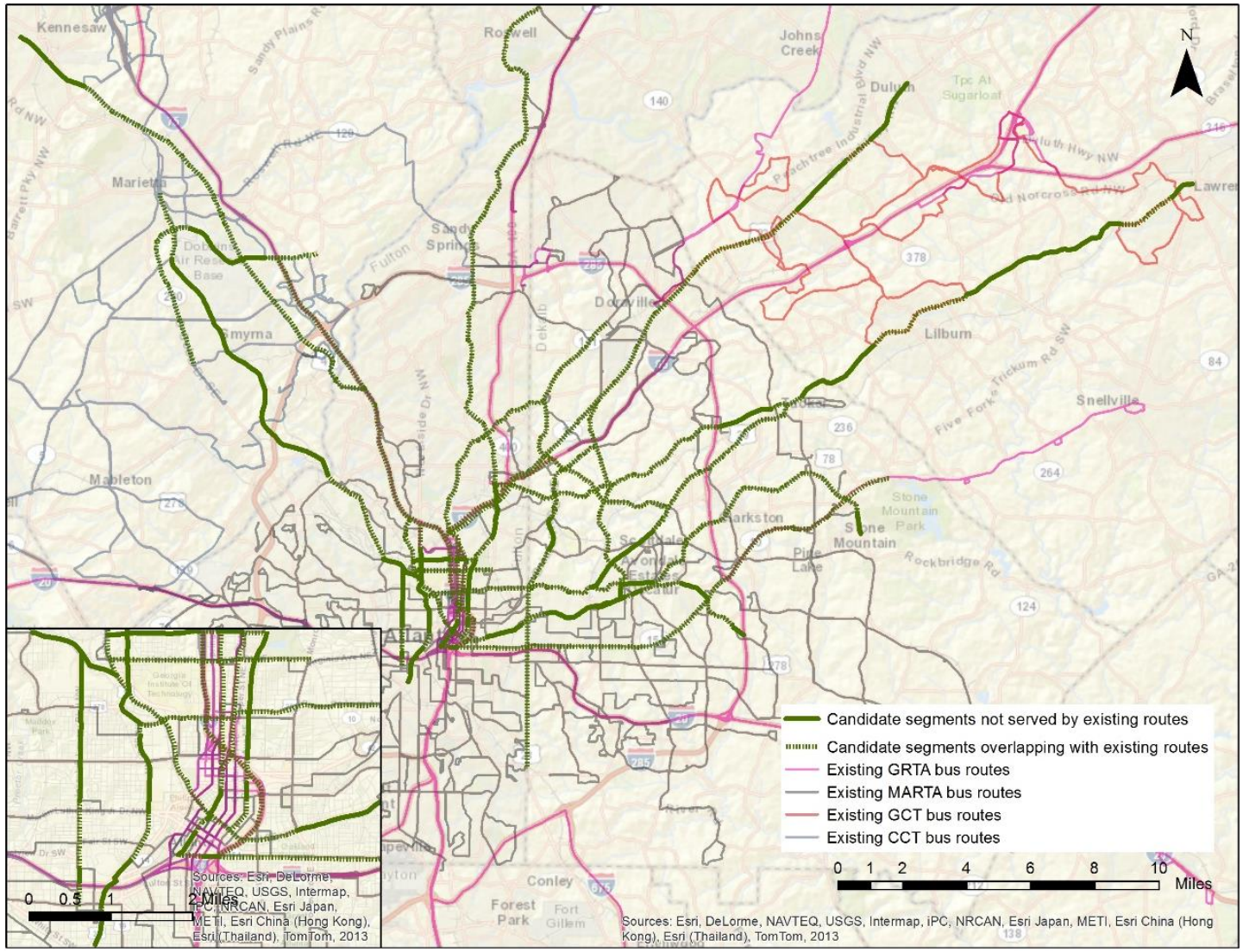

Figure 30 Current Bus Service of Candidate Corridors

3.2.2.4 Comparison with existing plans

3.2.2.4.1 PLAN 2040

PLAN 2040 is the latest Regional Transportation Plan (RTP) prepared by Atlanta Regional Commission (ARC), the Metro Atlanta's Metropolitan Planning Organization (MPO). In the part regarding managed lanes on principal arterials, projects are grouped into three different levels of status: Aspiration, long range, and programmed (Figure 31).

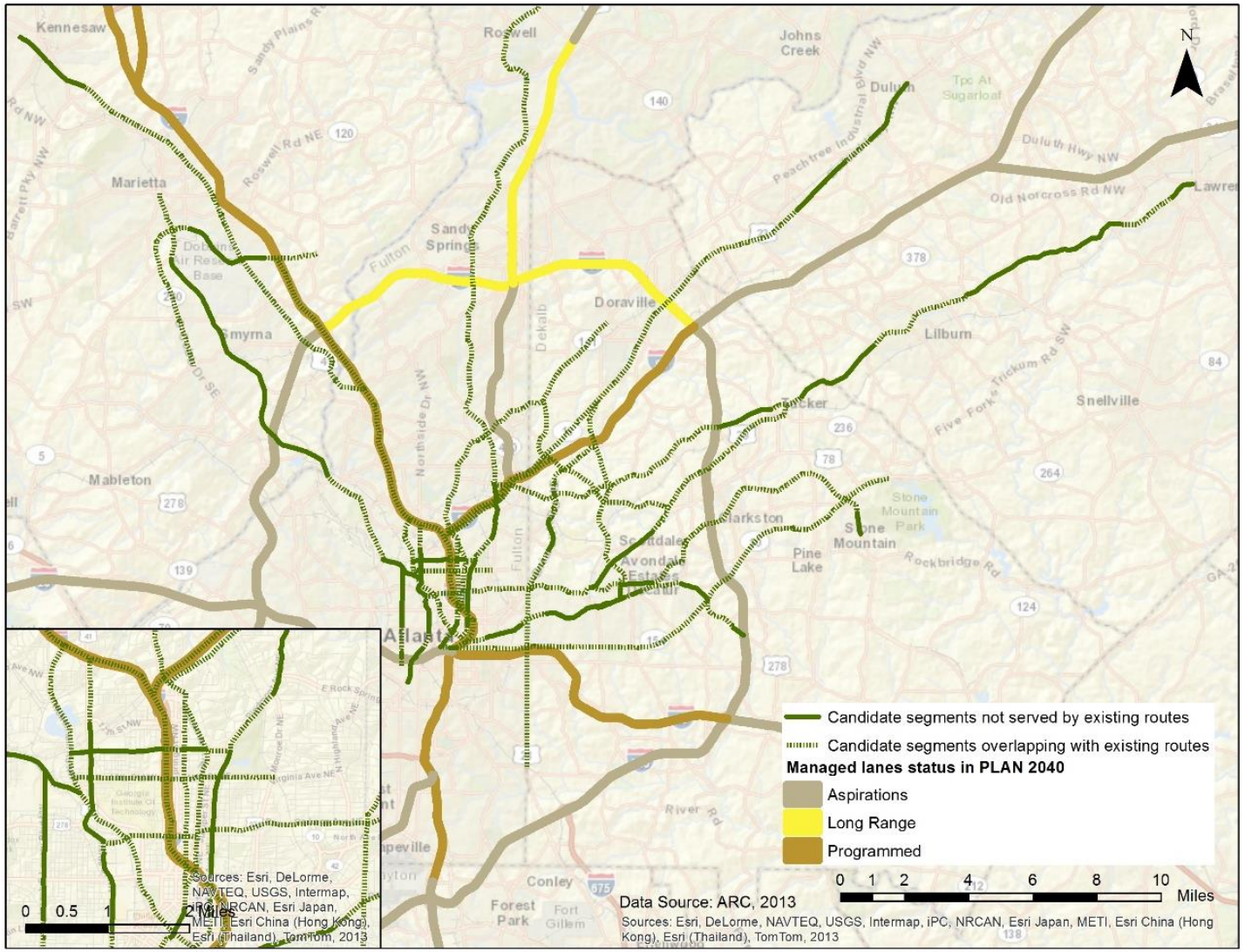

Figure 31 Managed Lane Status in PLAN 2040

Through an overlay analysis, it turns out that candidate corridors will be able to take advantage of the programmed managed lanes on I-85 and /or I-75 as follows (Figure 32):

- Cobb Pkwy (Kennesaw-Marietta-Cumberland) – I-75;
- Cobb Dr (Smyna) - Delk Rd (Delk Road)- I-75;
- I-75- Northside Dr (Georgia Tech-Georgia World Congress Center-Falcon's stadium) – Whitehall St (West End);
- I-75 – Howell Mill Rd (Midtown West) – Marietta St (Coca Cola - Georgia Aquarium - CNN Center - Centennial Olympic Park - Downtown); and
- Buford Hwy (Duluth-Norcross-Peachtree Comers-Doraville-N Druid Hills) – Northeast Expressway.

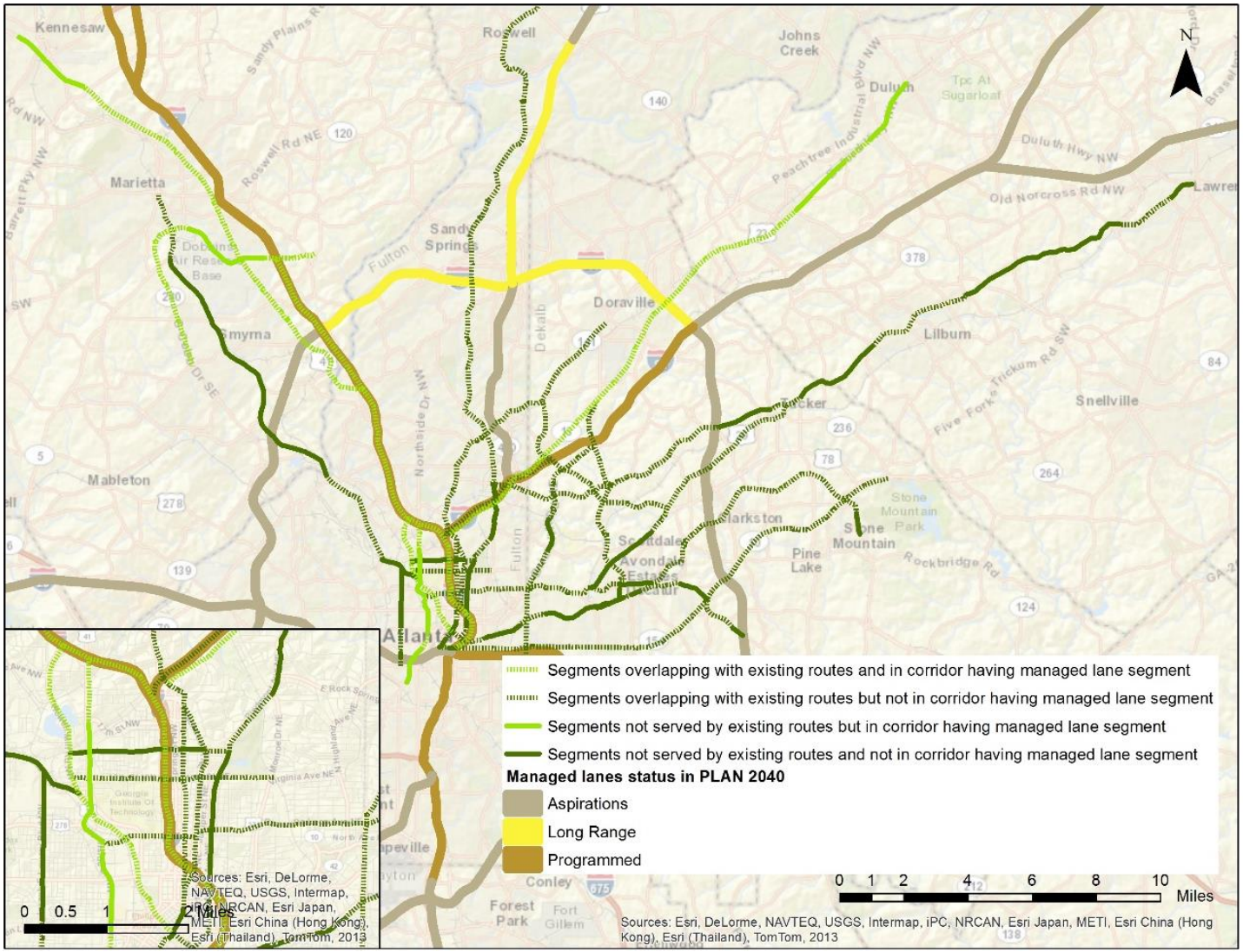

Figure 32 Candidate Corridors Having Managed Lane Programed

In PLAN 2040, rail capital projects, including commuter rail, heavy rail, high capacity rail, and streetcar, are categorized into Aspirations and Long range (Figure 33).

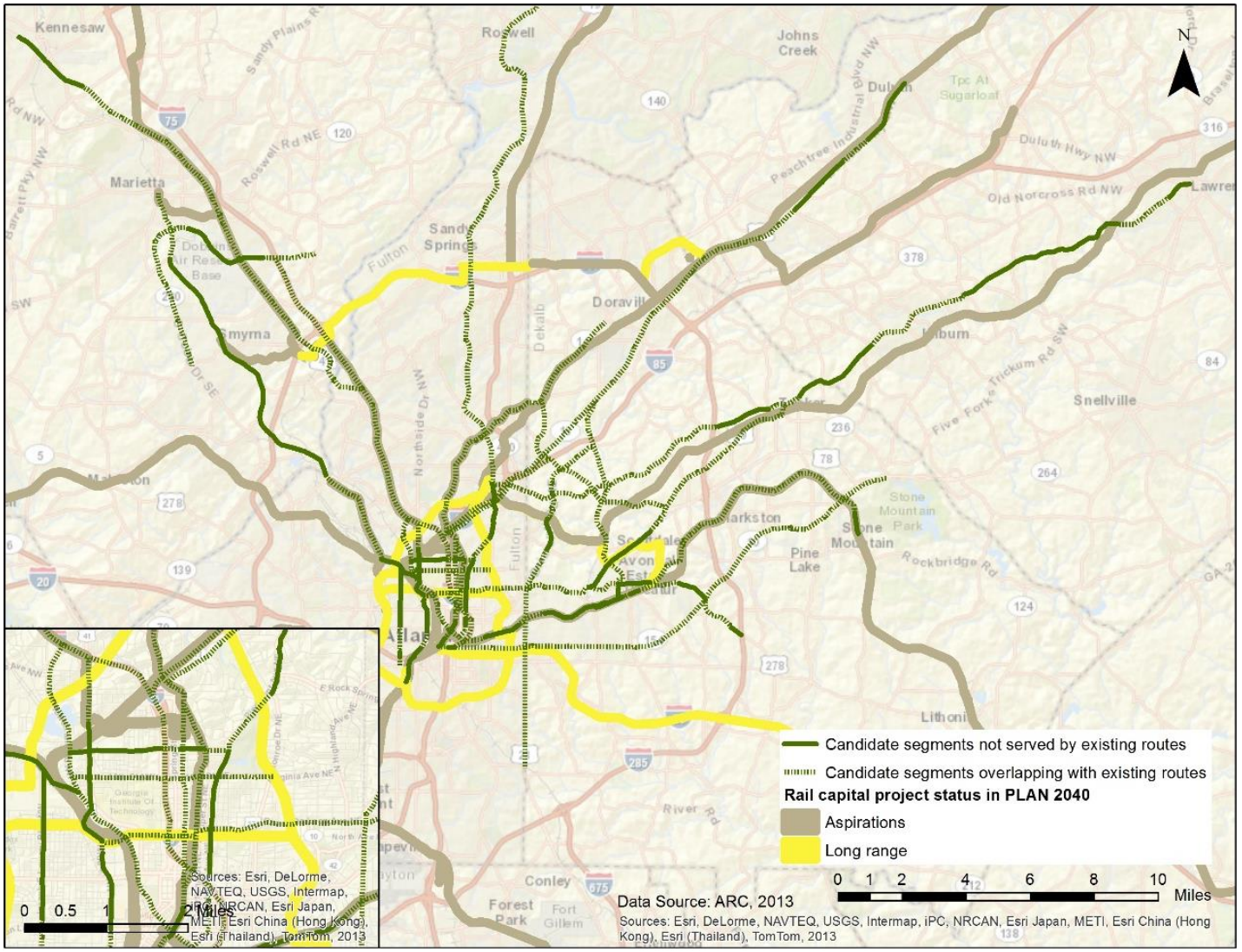

Figure 33 Rail Capital Project Status in PLAN 2040

While none of the rail projects are programmed, they represent ARC's projection of mass transit needs in these corridors. Through an overlay analysis, a couple of candidate BRT/BHLS corridors which are sharing segments with the proposed rail corridors were identified (Figure 34):

- Cobb Pkwy (Kennesaw-Marietta-Cumberland) – I-75;
- Cobb Dr (Smyna) - Delk Rd (Delk Road) - I-75;
- Atlanta Rd (Marietta-Smyrna) - Marietta Blvd-Marietta St (Downtown) - Decatur St – DeKalb Ave – College Ave- N Avondale Rd;
- I-75- Northside Dr (Georgia Tech-Georgia World Congress Center-Falcon's stadium) – Whitehall St (West End); and
- Buford Hwy (Duluth-Norcross-Peachtree Comers-Doraville-N Druid Hills) – Northeast Expy; Peachtree Blvd (Chamblee)-Peachtree Rd (Brookhaven-Lenox-Buckhead-Midtown-Downtown); and
- Main St (Stone Mountain) - E Ponce De Leon Ave (Decatur) - W Ponce De Leon Ave - Ponce De Leon Ave – North Ave (Georgia Tech-CocaCola).

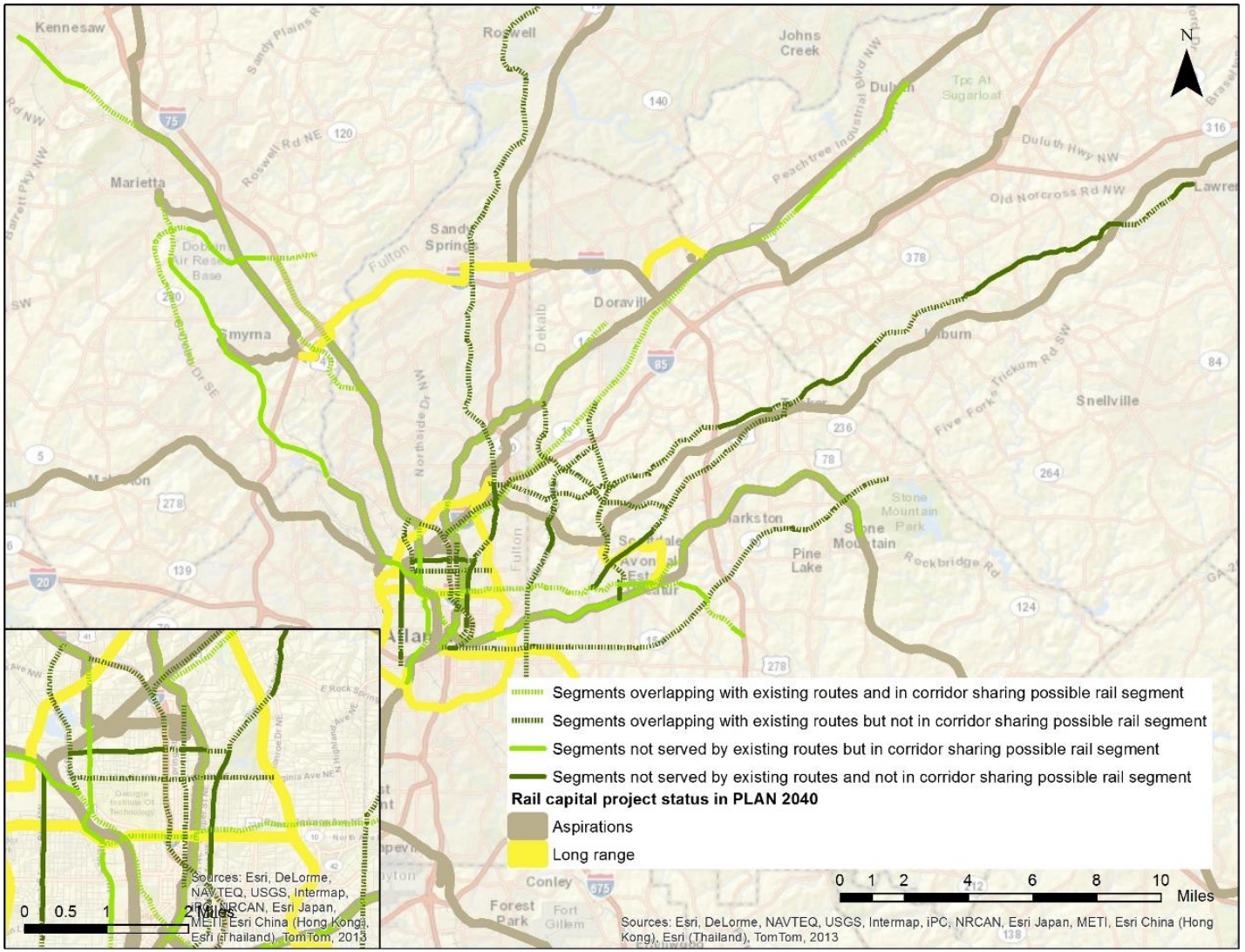

Figure 34 Candidate Corridors Overlapping with Future Rail Capital Projects

3.2.2.4.2 Connect Atlanta plan

Prepared in 2008, the Connect Atlanta Plan is the City of Atlanta's first Comprehensive Transportation Plan (CTP). The plan developed an evaluation matrix for transit projects and recommended 95 miles of rail transit and high-frequency bus transit. 18 projects were selected for the final project list and were divided into three tiers. Three projects in the second tier (Table 23) are related to the corridors identified in this paper (Figure 35):

- Atlanta Rd (Marietta-Smyrna)-Marietta Blvd-Marietta St (Downtown);
- Howell Mill Rd (West Midtown)-Marietta St (Downtown); and
- Alpharetta St (Roswell) – Atlanta St – Roswell Rd (Sandy Springs) – Piedmont Rd (Lindbergh) – Piedmont Ave (Midtown-Downtown).

Note that while the proposed Beltline Streetcar is in the first tier and has been a hot topic in recent years, there was no segment from the Beltline showing up in the analysis of this paper. That result reflects that the goal of this paper was to identify corridors with high travel demand that link existing activity centers and thus could potentially support enhanced bus service and meet needs of more transit dependent populations. The Beltline, on the other hand, proposes development corridors where existing population densities and activities show no demand nor meet existing needs.

Table 23 Projects in Connect Atlanta Related to Candidate Corridors (DPCD 2008)

TR-013	Piedmont / Roswell Road Transit	4.3 miles of high frequency bus transit (10-minute headways with appropriate physical pedestrian streetscape improvements and permanent transit amenities along Roswell Road and Piedmont Road.
TR-006A, TR-006B	Northwest Regional Light Rail Transit Corridor - Marietta St. / NW BeltLine	High speed/frequent LRT service with limited stations. **Option A.** Light Rail Transit on new exclusive alignment in shared right-of-way from Cobb County to Ga Tech and the Coca Cola Head Quarters, approximately via Marietta Blvd. to Marietta Street to 8th Street to Tech Parkway to Luckie Street. Then the LRT shifts to mixed flow alignment from Luckie Street to MARTA's North Avenue Station, approximately 1/2 mile, via North Avenue. The Alignment continues in mixed flow alignment to City Hall East and the Beltline, approximately 1.5 miles, via Ponce De Leon Blvd. Six potential stations in the City of Atlanta (Bolton Road, Carrol Drive, Beltline, Howell Mill, Luckie Street, MARTA's North Avenue Station, Piedmont Road, Boulevard, City Hall East (Beltline).**Option B** (Stops at Moores Mill, Huff Road area, Piedmont Hospital & Lindbergh) Instead of following Marietta to the southeast into downtown, it will now take Chattahoochee Road and then curve to the north around Ellsworth Industrial Road, following Beltline rail to the Lindbergh MARTA station.
TR-014	Moreland Avenue Transit	6.4 miles of high frequency bus transit (10-minute headways) with appropriate physical pedestrian streetscape improvements and permanent transit amenities along Moreland Avenue.

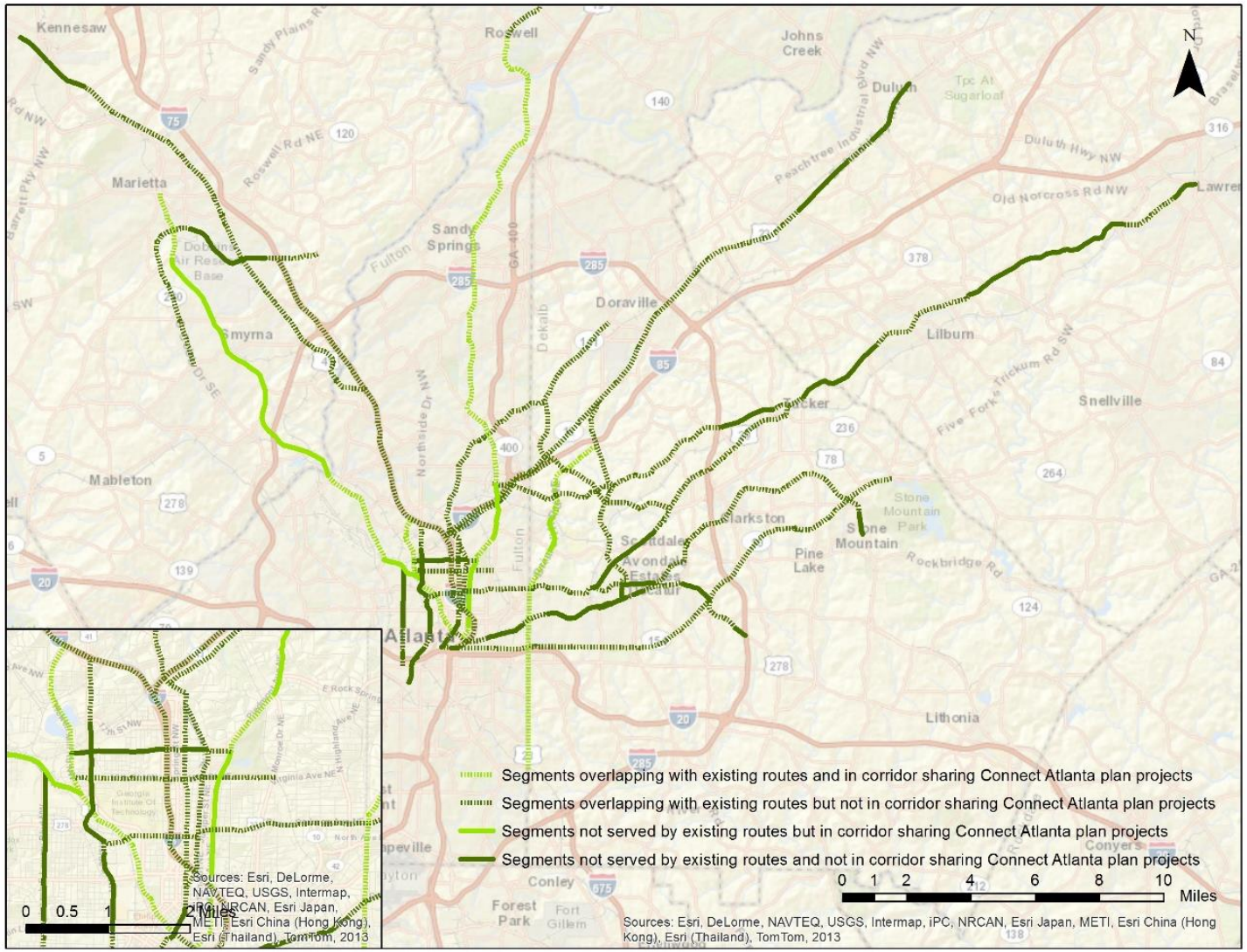

Figure 35 Candidate Corridors Overlapping with Connect Atlanta's Prioritized Transit Projects

3.2.2.5 Summary of Candidate Corridors

Combining the overlapping with managed lane, rail capital projects in PLAN 2040 and transit projects in Connect Atlanta, a summary of BRT/BHLS candidate corridors was completed (Figure 36, Table 24).

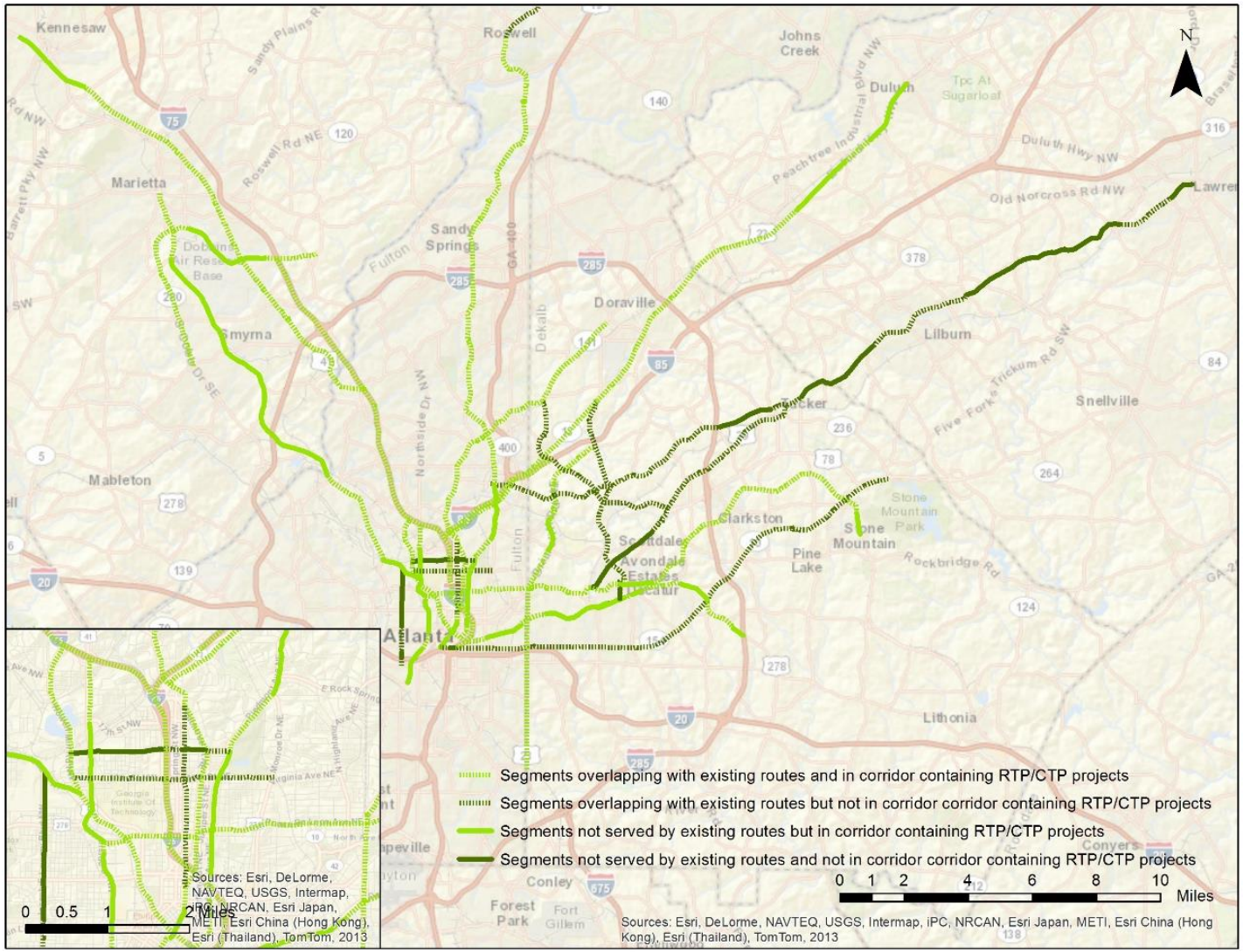

Figure 36 Summary of Candidate Corridors

Table 24 Summary of Candidate Corridors

Corridor	Sharing segments with PLAN 2040 managed lane projects	Sharing segments with PLAN 2040 capital rail projects	Sharing segments with Connect Atlanta
Cobb Pkwy (Kennesaw-Marietta-Cumberland) **- I 75**	Yes	Yes	No
Cobb Dr (Smyna) **- Delk Rd** (Delk Road)**- I-75**	Yes	Yes	No
I-75- Northside Dr (Georgia Tech-Georgia World Congress Center-Falcon's stadium) **– Whitehall St** (West End)	Yes	Yes	Yes*
I 75 – Howell Mill Rd (Midtown West) **– Marietta St** (Coca Cola - Georgia Aquarium - CNN Center - Centennial Olympic Park - Downtown)	Yes	No	Yes
Buford Hwy (Duluth-Norcross-Peachtree Comers-Doraville-N Druid Hills) **– Northeast Expy**	Yes	Yes	No
Atlanta Rd (Marietta-Smyrna)**-Marietta Blvd-Marietta St** (Downtown)**-Decatur St – DeKalb Ave – College Ave- N Avondale Rd**	No	Yes	Yes
Peachtree Blvd (Chamblee)-**Peachtree Rd** (Brookhaven-Lenox-Buckhead-Midtown-Downtown)	No	Yes	No
Main St (Stone Mountain)**-E Ponce De Leon Ave** (Decatur) **- W Ponce De Leon Ave- Ponce De Leon Ave – North Ave** (Georgia Tech-Coca Cola)	No	Yes	No
Alpharetta St (Roswell) **– Atlanta St – Roswell Rd** (Sandy Springs**) – Piedmont Rd** (Lindbergh) **– Piedmont Ave** (Midtown-Downtown)	No	No	Yes
Joseph E Lowery Blvd (Upper west-Ashby-West End)	No	No	No
14th St (West Midtown-Midtown)	No	No	No
10th (West Midtown-Georgia Tech-Midtown-Piedmont Park)	No	No	No
I 75/I-85-W Peachtree St (Midtown-Georgia Tech-Downtown)	No	No	No

*Connect Atlanta Plan was amended to identify Northside Dr as a transit corridor in 2013

CHAPTER 4 IMPLEMENTATION STRATEGIES OF ENHANCED BUS SERVICE IN METRO ATLANTA

4.1 Listen to, Guide, and Inform the Public

4.1.1 Comprehensive (Potential) Customers Survey

In the Metro Atlanta area, transit on-board surveys have been consistently conducted by ARC and MARTA. ARC has been focusing on the origin-destination (OD) data and more recently has begun to shift to an activity based analysis, while MARTA has been collecting both OD data through on-board surveys and customer satisfaction data through a Quality of Service Customer Survey process. But MARTA didn't separate the satisfaction data on trains and buses until the 2009-2010 survey (MARTA 2011). Also, the Quality of Service Customer Survey is stress customer satisfaction with current service with few requests for input on specific improvement strategies or rider preference. In addition, MARTA hasn't conducted systematic outreach to non-rider groups.

If the regional planning authority and transit agencies want to maintain the existing rider base, increase the choice rider pool and eventually realize the travel mode shift as a region, it is essential to find out why people are, and even more importantly, why people are not taking transit. Does the bus have to travel faster on dedicated lanes to attract people on board or could providing complimentary Wi-Fi or power charger provide a short term fix? To what extent could real-time information work as a replacement of increasing service frequency? There is no better way to find out these "why"s, "which"s, and "what"s than asking the target group directly.

4.1.2 Guide the Public Perception

As a Deep South and car-dominant metropolitan area, the resistance or indifference to public transportation has been here and will exist for a long time. The most obvious symbol is that, according to the enabling legislation, Georgia's gasoline tax cannot not be used to support transit. And unfortunately among all the transit modes, the cheapest to implement and maintain – bus - gets the least support. The public favors trains and are willing to spend tens of millions of money on less than 3 miles of streetcar (AtlantaStreetcar 2013), while performance-wise, the streetcar does nothing better than bus.

Also, since even a lot of agencies have been mislabeling their service as discussed in Chapter 1, it is hard for the public to grasp how big the differences there are between BRT, BHLS, and local conventional basic services.

Again, it depends on the transit agencies and media to work together to educate the general public and transform the perception. Information will empower the public to make wiser investment decisions and eventually change the anything-but-supportive legislation.

4.1.3 Propagation of Projects

The I-85 HOT lane project is a good case to explain how important it is to inform the public about what projects are going on. When the I-85 HOT lane first opened in early October 2011, there weren't many patrons and most media coverage took a less-than-friendly tone (Samuel 2011). But as time goes by, it begins to function as it is supposed to. A major reason for its early trouble was that there wasn't much publication of the HOT lane project

in advance, and a lot of commuters didn't know about it until its opening. The same principle could be applied to bus projects: if people don't know what is going on, they won't know how to react to it.

Related to the propagation of enhanced bus service, a more effective, but probably more challenging way than public meetings and media reports is to put the demonstration projects into the core of the city, on major corridors, and /or between activities centers. Everyone will see it and know about it because it is hard to ignore something that is happening in the busiest area. This is the strategy that has been utilized in the Los Angeles Metro Rapid system: the Demonstration Projects were put into two key corridors and they successfully generated more support.

4.2 Collaboration between Agencies

4.2.1 Transit Agencies

Currently there are four agencies providing bus service in the four counties of Fulton, DeKalb, Cobb, and Gwinnett: GRTA, MARTA, CCT, and GCT. Although there are a couple of connection points where riders can transfer from one system to another, such as Cumberland and Arts Center, there are few routes (except express service which mainly use the Interstate highways) that run across county boundaries (except Fulton-DeKalb) in order to service a corridor continuously. Also, each of the transit operators has its own fare collection system. Although one can make a connection trip from one system to another, it is not a unified system in which the passenger can jump on any system with a single card any time. What if all the agencies could have a more aggressive collaboration on route

planning and fare collection? It would save the customers' time from the process of transfer and ownership of multiple transit cards, which collectively would make a big difference in the transit riding experience.

Part of the comprehensive route planning effort should be the creation and enhancement of connection points and transit hubs. The Multi-Modal Passenger Terminal (MMPT) planning in the Gulch area is a good start. While the MMPT is planned to become the transit core, additional major nodes are needed to form a complete and strong network. To strengthen the existing nodes such as North Ave. and to create new nodes such as the state-owned site to the west of Atlantic Station, any enhanced bus service should consider the connection points with other enhanced bus and rail services. Examples of such practice include:

- In Seattle area, King County BRT and Snohomish County BRT meet at Aurora Village Transit Center; and
- In Eugene-Springfield area, Franklin EmX and Getaway EmX meet at Springfield Station.

4.2.2 City / County and GDOT's Role

Transportation and land use go hand in hand. A comprehensive plan including how to provide transit to serve populous areas and activity centers and how to manipulate land use through zoning to encourage transit usage is highly desirable and should be done through the collaboration between the city/ county government and transit agencies.

Another game changer would be GDOT, as it owns the right of way of a majority of the arterial roads. Although GDOT currently prevents transforming existing lanes into transit-dedicated lanes, it would be very helpful if it supports varied forms of semi-dedicated lanes on arterials as they presently allow transit vehicles to use HOV / HOT lanes. GDOT could maintain a minimum ROW along its arterials, including space for sidewalks and potential bus stops. It could ensure that enhanced bus service could be accommodated in the future as needed.

4.3 Provide and Acknowledge a Variety of Services

4.3.1 Provide a Variety of Services

As discussed in the case studies, different areas and corridors have different needs of transit service, and the ridership of each area or corridor can only justify certain bus services. Enhanced bus service should be used as the bones of the system, with local bus/ response-based service/jitney and/or other transit forms as the branches to complete the network. Over-serving may be perceived even worse than under-serving, as people will be less than happy seeing an empty bus running, especially if the road is congested.

In the same light, there is no need to pursue the highest standard bus service regardless of market. According to the context, alternatives as well as incremental improvement strategies could be considered:

- A segment or multiple segments of dedicated lanes could be considered as an alternative to full-length dedicated lanes;
- Two split one-way route as an alternative to a two-way route on the same road;

- Rush-hour dedicated lanes as an alternative to physical grade-separated lanes;
- Reversible dedicated lanes as an alternative to one dedicated lane per direction;
- Combination of BRT/BHLS and local services as an alternative to running enhanced bus service all day;
- Start with a segment of a corridor before extending to its full length; and
- Start with less stops before the density could justify more.

4.3.2 Brand Services Accordingly

With the creation of different levels of service, it is crucial to brand them accordingly to stress their differences, which could help the customer to understand the system and realize what it takes to reach the next level.

Branding should go beyond the name. The appearance of vehicles, interior of vehicles (material of seats, space between rows), facilities onboard (real-time display, stop notification, Wi-Fi, power socket), and design of the stops/stations are all components of the branding, to new a few. A train-like appearance, for example, is part of the branding strategy of Eugene-Franklin Emma system to gain public support.

4.4 Plan in Advance

If detailed studies show the necessity of an enhanced bus service, the timeline for delivering should be kept in mind. Any BRT project requiring physical construction will take much longer to happen than a BHLS project of sharing lanes, increasing service frequency, or upgrading fleet. For example:

- Franklin EmX (60% physically dedicated-lane) was under planning since 1996 and opened in 2007;
- Grand Rapids, Kentwood, and Wyoming's Division Avenue BRT (semi-dedicated lanes sharing with right-turn vehicles) was under planning since 2002 and will open in 2012;
- New York M15 SBS (rush-hour semi-dedicated/sharing lane) was under planning since 2006 and opened in 2010; and
- Demonstration project (mixed traffic) of Los Angeles Metro Rapid was under planning in 1999 and opened in 2000.

Figure 37 shows the timeline of Geary Corridor BRT project in San Francisco which includes segments of dedicated lane.

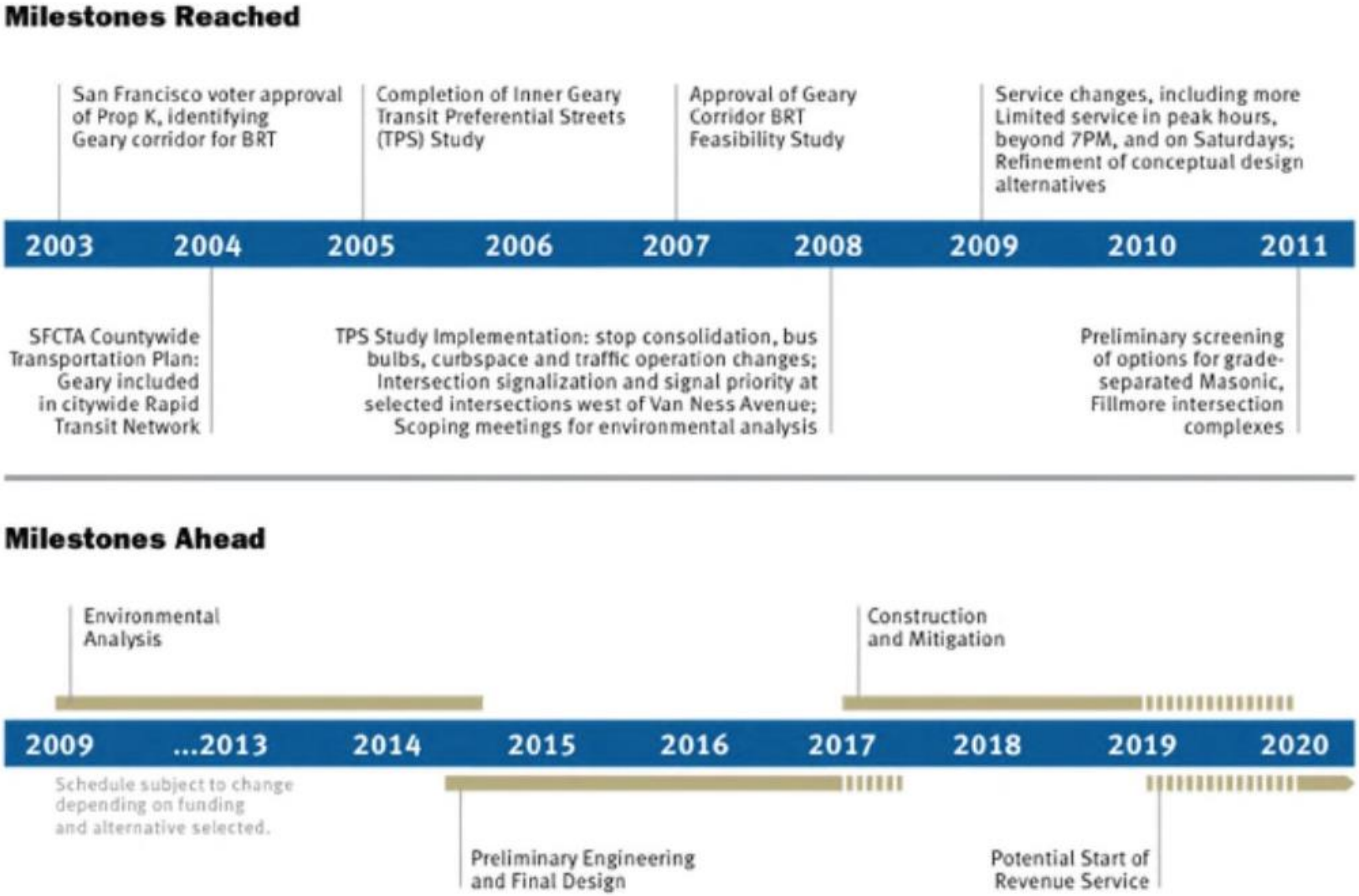

Figure 37 Geary Corridor BRT Project Timeline (SFMTA 2012)

4.5 Prioritize Key Corridors

The importance of addressing the demand and gaining support for key corridors has been discussed in the public outreach and branding sections. But it is so critical to the success of the whole system that it is worth highlighting again.

While the corridor features vary among the 19 identified benchmark cases, they share two characteristics in common: first, linking activity centers or activity center-major transit connection points; second, relatively simple and continuous routes with little turning movement required.

Except for customer satisfaction, the most two common evaluation criteria against enhanced bus service are corridor ridership gain and travel time reduction. While travel time reduction could be realized through consolidation of stops and upgrade of vehicles, there is little room for corridor ridership gain if it is neither a highly developed corridor nor a less developed corridor but with incentives (such as zoning or financial incentives) for denser development. Note that corridor ridership is the indicator of interest rather than route ridership unless they are one and the same, which happens when a corridor was not previously served by any route. Looking only at ridership increase of enhanced bus service routes, there is a risk, and a good chance, that the increase of route ridership is simply a shift from local service buses to enhanced service buses. Part of the goal is to provide existing riders with better service, but from a cost effective point of view, expanding the rider pool or increasing transit trips should be a main purpose.

4.6 Right of Way

There are a few potential ways to gain the ROW along the candidate corridors for enhanced bus service:

- Zoning;
- MARTA condemn the land;
- GDOT authorizes the right to use its ROW to transit agencies;
- Railroad companies including Norfolk Southern and CSX leases the ROW of abandoned railroads to transit agencies; and
- The related county/city jurisdictions condemn the ROW and transfer to transit agencies.

4.7 Service Span and Frequency

Long service spans should be considered for enhanced bus service by all transit agencies. As discussed in the case study sections, among 19 identified successful enhanced bus service routes/ systems:

- All but two operate seven days a week;
- All but one operate more than 15 hours per day from Monday to Saturday; and
- All but two operate for slightly shorter period on Sunday compared to Saturday.

There are several 24/7 systems: either the enhanced bus services run 24/7 themselves, or there is a supplementary local route to fill in the gap. There are also systems providing special service spans for weekends, the concept of which could be borrowed to adjust service spans to serve special events.

Varied service frequency should be considered too. All but two benchmark cases use varied service frequency during peak hours and non-peak hours, but the peak hours are not the same from one case to another. The peak hours are decided by local travel behavior (when most people start the day, how active evening life is, etc.) and corridor travel pattern (dominant commuter trips, non-home-based trips during the day, recreational trips, etc.). A study of the variation of corridor ridership and travel patterns through a day should be conducted to inform the decision on service frequency. An alternative would be to adjust the frequency based on the ridership and occupancy after the route begins to operate. Or both.

However frequencies are assigned to different times during the day, frequencies below 15 minutes for peak hour and below 20 minutes for non-peak hour should be taken as the minimum goal to achieve.

4.8 Transit Signal Priority (TSP)

All of the 19 benchmark cases except those running on controlled-access lanes have TSP as part of its Intelligent Transportation System (ITS). There is, however, little information about:

- How often this treatment actually works in terms of extending the green or shortening the red;
- How this treatment alone contributes to system performance in terms of the probability of extending the green long enough to let the bus pass or shortening the red enough to make the bus move faster; and especially,

- How this treatment performances when there is no dedicated lane, which means there could be other vehicles between the bus and the signal lights.

It would be beneficial to conduct or review further studies on the performance of TSP, and a cost-benefit comparison between installing TSP on buses and coordinating the traffic signals along the corridor to generate green wave traffic flow for all vehicles.

4.9 Dwell Time

4.9.1 Distance between Stops

Consolidating stops or increasing the distances between stops is not technically a method to reduce dwell time because it eliminates the dwell process as a whole. While stop consolidation could be tempting as it may appear to simplify the solution, it should be employed with caution. As the distances between stops increase, the distances riders need to walk to and from the stops increase too. For the same reason, it is more appropriate to align the stops with activity nodes such as shopping squares, apartment complexes, and university main entrances rather than sticking to a fixed stop interval throughout the route.

However, all things considered, fewer stops should be designed for BRT than BHLS, since high quality and rapid service are the extra goals of BRT systems.

4.9.2 Fare Collection

Proof of payment and ticket vending machines are the standard combination of off-board fare collection, which can greatly reduce the dwell time by reducing passenger boarding time. There is no delay for on-board ticket purchasing, and multiple-door boarding can be used. To make such a collection system work, it is vital to ensure at least two vending machines available at each stop as well as multiple payment options (cash, credit card, and smart card).

4.10 Vehicle

To improve air quality and be eligible to certain funding sources, most vehicles serving in enhanced bus service systems are using clean-energy propulsion systems such as hybrid electric and compressed natural gas.

At the same time, it is important for system planners to keep in mind that the appearance of the vehicles matters more to customers' perception of the system. Innovative design can gain more public popularity with a marginal cost such as a train-like appearance. Also, there is little point to pursue in using super-long vehicles whose capacity far exceeds the projected ridership. Even in India, a country of extreme density and ridership, mini-BRT has been created to maintain a high frequency and serve relatively lower density corridors.

4.11 Funding

4.11.1 Federal Level

Except the three BRT-targeted grants mentioned in Chapter 2 (New Starts, Small Starts, and Core Capacity), there are two grants for enhanced bus service projects: First, Urban Area Formula Grants, which are for "public transportation capital, planning, job access and reverse commute projects, as well as operating expenses in certain circumstances" in "urbanized areas, which depend on public transportation to improve mobility and reduce congestion"; Second, Bus and Bus Facilities, which is for "capital projects to replace, rehabilitate and purchase buses, vans, and related equipment, and to construct bus-related facilities".

Also, there is potential of getting special congestion mitigation targeted grants if the proposed enhanced bus service can be statistically justified.

4.11.2 State Level

In the long run, it is crucial for the State to change the legislation and allow the allocation of gasoline tax revenue to fund transit projects. It is a battle of wills, but the success of one or two demonstration routes could facilitate the change in mindset.

4.11.3 Local Level

Beyond general tax revenues, there are several potential ways to fund enhanced bus systems, especially the O&M cost:

- First, by developing or leasing the land owned by transit agencies around the stops or stations (MARTA's Lindbergh Station is a typical model);
- Second, by promoting Transit Oriented Development (TOD) around existing stations/stops and establishing Community Improvement District (CID), which can generate funds;
- Third, by charging impact fees to special event organizers while providing extra service (longer span, higher frequency) in return; and
- Lastly, by adding service into Tax Allocation District (TAD) areas and getting support from TAD funds.

APPENDIX

Enhanced Bus Service Systems in the US 2013

The following table summarizes the operating and under implementation enhanced bus service corridors/systems in the United States up to August 2013. System basics such as corridor lengths, alignments, station numbers, and capital costs, as well as system performance measurements such as ridership and travel time changes are included to the best extent. Benchmark cases used in this paper are highlighted in yellow (or light grey if in b/w) and many other cases (mostly were under-implementation by the time this paper was written) that own valuable experience and/or are worth follow-up studies are highlighted in green (or dark grey if in b/w).

Table 25 Enhanced Bus Service Systems in the US (2013) (Levinson, Zimmerman, Clinger, Rutherford, et al. 2003, TCRP 2007, BTI 2008. NBRTI 2012b. a. ALC-BRT and EMBARQ 2013b)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
The Rapid Ride Red Line (Central Avenue)	Operating			2004	City of Albuquerque (ABQ RIDE)		Albuquerque	NM
VelociRFTA	Implementing	http://www.rfta.com/velociRFTA.html			Roaring Fork Transportation Authority (RFTA)		Aspen	Co
North Lamar/South Congress Bus Rapid Transit	Implementing				Capital Metro		Austin	
Silver Line Phase 1 (Washington Street)	Operating			2002	Massachusetts Bay Transportation Authority		Boston	MA
Silver Line 2 (Airport/Waterfront)	Operating			2004	Massachusetts Bay Transportation Authority		Boston	MA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
The Rapid Ride Red Line (Central Avenue)	11	Mixed traffic			N/A	N/A	Hybrid Electric
VelociRFTA	38.8	Mixed traffic			9	22	CNG
North Lamar/South Congress Bus Rapid Transit							
Silver Line Phase 1 (Washington Street)	2.4	Dedicated			13	20	
Silver Line 2 (Airport/Waterfront)	4	Dedicated bus tunnel & Mixed traffic			9	32	

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
The Rapid Ride Red Line (Central Avenue)		AVL, APC, real time information(stops, bus, internet), TSP		16	16	16	16
VelociRFTA		AVL, real time information (stations, vehicles), cameras (vehicles), smart card techniques, TSP, APC's, WIFI		10	15-30	10	15-30
North Lamar/South Congress Bus Rapid Transit							
Silver Line Phase 1 (Washington Street)		AVL, Real time information (Stops), TSP, smart card techniques		4	7	4	7
Silver Line 2 (Airport/Waterfront)		AVL, Cameras (Stations), smart card techniques		2	7	2	7

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
The Rapid Ride Red Line (Central Avenue)	N/A	5100	On board fare box,				
VelociRFTA			On board fare box, Proof of Payment, Ticket vending machines				
North Lamar/South Congress Bus Rapid Transit							
Silver Line Phase 1 (Washington Street)	13	15000	On board fare box				
Silver Line 2 (Airport/Waterfront)	20	11000	On board fare box, ticket vending machine				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
The Rapid Ride Red Line (Central Avenue)					N/A		
VelociRFTA					39.28		
North Lamar/South Congress Bus Rapid Transit						required federal funding 29	
Silver Line Phase 1 (Washington Street)					26		
Silver Line 2 (Airport/Waterfront)					600		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Jeffrey Corridor	Implementing	http://www.transitchicago.com/jump/			Chicago Transit Authority		Chicago	Il
Healthline (Euclid Corridor)	Operating	http://www.rtahealthline.com/healthline-what-is.asp		2008	Greater Cleveland Regional Transit Authority		Cleveland	OH

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Jeffrey Corridor	16	less than 20% dedicated bus lanes & Mixed traffic	Curb-side		19	53	Hybrid diesel
Healthline (Euclid Corridor)	9.4	Dedicated			58	N/A	Hybrid Electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Jeffrey Corridor		AVL, real time information (Stations, vehicles), Cameras (Vehicles), TSP, smart card techniques		7	11	10	12-14
Healthline (Euclid Corridor)		AVL, APC, real time information(stations, vehicles), cameras(Vehicles), TSP, Smart card techniques	24/7	5	15	5	15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Jeffrey Corridor			Proof of payment, ticket vending machines				
Healthline (Euclid Corridor)	11	15800	Proof of payment, ticket vending machine				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Jeffrey Corridor					11		
Healthline (Euclid Corridor)				Cleveland RTA officials told us that the Healthline has contributed to rail-like economic development benefits, and the amount of development is impressive given Cleveland's economic challenges. Officials estimate that between $4-$5 billion worth of investment has occurred in the corridor since the Healthline began operations; however, much of that development is associated with nearby institutions including hospitals and universities.	200		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Franklin EmX	Operating	http://www.ltd.org/search/showresult.html?versionthread=45a4b83927fba5cb751c741bf4ac81e3	1996	2007	Lane Transit District	downtown Springfield to downtown Eugene	Eugene	OR

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Franklin EmX	4	60% Dedicated	60% of the route has dedicated median two way bus lanes or a two way reversible bus lane		10	4	diesel-electric hybrid articulated buses

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Franklin EmX	on-level boarding	AVL, APC, cameras(vehicles), TSP, CAD	5:40AM-11:00PM on Weekday; 6:50AM-11:00PM on Sat; 7:45AM-8:20PM on Sun	10	10	10	10

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Franklin EmX	17	6000	off board fare collection	35%	14months	4	

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Franklin EmX				City officials informed us that $100 million construction projects are under way downtown near the Franklin EmX line, including a boutique hotel, office space renovations, and expansions to a community college. City officials also said that University of Oregon is looking to lease space downtown and that there has been developer interest in new student housing. Although these officials expect land values to increase along Franklin Ave., they noted it is hard to measure the extent to which BRT is contributing to the increase.	$25 million, or $6.25 million per mile. (System construction: 12m; planning and design: 6m)	The primary source of funding was $19.2 million of Federal Transit Administration Section 5307 and 5309 funds (detailed cost in nbrti study)	

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
US 36 BRT	Implementing				RTD		Denver	
EmX Springfield Gateway	Operating	http://www.ltd.org/search/showresult.html?versionthread=d38519362672c662c61a9300c1dd78be		2011	Lane Transit District	downtown Springfield to medium density residential area and a major shopping center	Eugene	OR
SWIFT bus rapid transit	Operating	http://www.commtrans.org/swift/; http://www.commtrans.org/Projects/Swift.cfm		2009	Snohomish County Public Transportation Benefit Area (Community Transit and Everett Transit)	between Everett and Shoreline	Snohomish County	WA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
US 36 BRT							
EmX Springfield Gateway	7.8	Dedicated & Semi-dedicated			15		Hybrid Electric
SWIFT bus rapid transit	17	7 miles dedicated lane and 10 miles mixed traffic	curb-side		28	15	Hybrid diesel electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
US 36 BRT							
EmX Springfield Gateway		AVL, APC, cameras(Vehicle), TSP	5:40AM-11:00PM on Weekday; 6:50AM-11:00PM on Sat; 7:45AM-8:20PM on Sun	10	15	10	15
SWIFT bus rapid transit	level-boarding	AVL, real time information (stations), TSP, cameras (vehicles),smart card techniques	5AM-7PM Mon-Sat; no service on Sun	12	20	12	20

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
US 36 BRT							
EmX Springfield Gateway			off board fare collection	39%	3months		
SWIFT bus rapid transit	23	1699(2009 Dec), 2367(2010Jan), 2660 (2010Feb), 4300 (2012)	Proof of payment, ticket vending machines	11%	1 year		

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
US 36 BRT						Required federal funding 350	
EmX Springfield Gateway					41.3	required federal funding 14.80	
SWIFT bus rapid transit					29.5		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Mountain Links BRT	Implementing	http://www.mountainlink.az.gov/			NAIPTA	downtown Flagstaff, NAU campus, Woodlands Village residential & commercial areas.	Flagstaff	AZ
MAX (Mason corridor)	Implementing				City of Fort Collins		Fort Collins	Co
Ctfastrak (New Britain-to-Hartford Busway)	Implementing	http://www.ctfastrak.com/		2015	CONDOT		Hartford	

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Mountain Links BRT		Dedicated lane on NAU campus;Mixed traffic					
MAX (Mason corridor)	5.2	3.8miles of dedicated lane			14	6	CNG
Ctfastrak (New Britain-to-Hartford Busway)	9.4	dedicated			11	31	hybrid diesel-electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Mountain Links BRT							
MAX (Mason corridor)	on-level boarding	AVL, real time information (Stations, vehicles), Cameras (Vehicles), TSP, smart card techniques		10	10	10	10
Ctfastrak (New Britain-to-Hartford Busway)	on-level boarding	AVL, real time information (Stations, vehicles), Cameras (Vehicles), Computer Aided Dispatch, TSP		3-7	5-15	3-7	5-15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Mountain Links BRT							
MAX (Mason corridor)	15 (est)		Proof of payment, ticket vending machines				
Ctfastrak (New Britain-to-Hartford Busway)			ticket vending machines				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Mountain Links BRT		NAU students free ride with ID				required federal funding 6.24	
MAX (Mason corridor)					$74.19	required federal funding 59.35	
Ctfastrak (New Britain-to-Hartford Busway)				in 2013, the state is giving the city $500,000 to plan downtown redevelopment to take advantage of economic growth possibilities.	$572.69 million	New Starts funding share is $275.30	

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Route B – City Express!	Operating	http://www.thebus.org/		2000	TheBus (Hawaii DTS)	Kalihi and Waikiki, one of the busiest transit routes in Honolulu	Honolulu	HI
Route A – City Express!	Operating	http://www.thebus.org/		1999	TheBus (Hawaii DTS)	linking University of Hawaii and Waipahu, including a stop at the Kalihi Transit Center	Honolulu	HI

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Route B – City Express!	8	mixed traffic			41	N/A	hybrid diesel-electric
Route A – City Express!	19	mixed traffic					Hybrid Electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Route B – City Express!		AVL, Real time information (Vehicle)		15	15	15	15
Route A – City Express!		AVL, Real time information (Vehicle)		15	30	15	30

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Route B – City Express!	N/A	6300	On board fare box			20% compared to local service, (2000-2007)	
Route A – City Express!	N/A	9000	On board fare box			43% compared to loc. service, (1997-2007) 1% compared to systemwide service	

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Route B – City Express!							
Route A – City Express!							

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Metro Area Express (MAX) - Main	Operating			2005	Kansas City Area Transportation Authority	cross-region routes and express services to downtown and suburban job sites	Kansas City	MO

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
	9	exclusive bus lanes during peak hours (dedicated northbound lanes during the morning rush hour and dedicated southbound lanes during the evening rush) for about 3.5 miles between County Club Plaza and River Market.Mixed traffic			47	14	Diesel

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
		AVL, Real time information (Internet), Cameras (Vehicles), Smart card techniques, TPS	5AM-1AM everyday	9	15	15	30

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
	N/A	4800	On board fare box	30.0%	12 months		23%

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
	$1.5 free transfer	free transfer		Local officials told us that BRT has helped Troost Ave. position itself for future development. The city recently received a $25-million federal grant for urban reinvestment, which is being used for a variety of streetscape improvements within a 150 square block area that includes three Troost MAX stations.40 Metro Rapid System, According to transit agency staff, the area was chosen for federal investment in part due to its proximity to the BRT.	21 in total;	Dec 2005 Congress awarded $12.3 million for further MAX expansion. An additional $6.3 million was awarded in 2007 to develop MAX along the Troost corridor. $4.2 million from local	on-board survey (Nov 2005) found that Max rated excellent on all 20 factors, that service quality was "High" and that riders would definitely recommend MAX. survey in Fall 2007, rating services on a scale of 1(worst)-10(best), found that riders rated MAX above 8 on all criteria. Quality of service was rated an 8.6.

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Route C – City Express!	Operating	http://www.thebus.org/		2000	TheBus (Hawaii DTS)	Makaha (Leeward Oahu) to downtown Honolulu and Ala Moana Center	Honolulu	HI
Strip and Downtown (SDX)	Operating	http://www.rtcsnv.com/		2004	Regional Transportation Commission of Southern Nevada (RTC)	strip and downtown	Las Vegas	NV

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Route C – City Express!	39	mixed traffic			50		hybrid diesel-electric
Strip and Downtown (SDX)	7	4.5 miles dedicated lane sharing with other transit and right-turning vehicles	two-one-way pair on curb side		22	60	Hybrid Electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Route C – City Express!		AVL, Real time information (Vehicle)			15	10	15
Strip and Downtown (SDX)	level-boarding	AVL, Real time information (Internet), Cameras (Vehicles), Smart card techniques, TSP, APC, CAD, optical guidance system	9AM to Midnight daily; Has a local route Deduce with more stops running 24/7	12	15	12	15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Route C – City Express!	N/A	4000	On board fare box			7% compared to local service, (2000-2007)	
Strip and Downtown (SDX)	14	14007	Proof of Payment, Ticket vending machines	0.25	First 5 month (7/2004-12/2204)	37% compared to pre-MAX route 113 standard bus service (minimum reducation 26%) 2005data	

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Route C – City Express!							
Strip and Downtown (SDX)					20.3 (gobrt)		Feb 2005 survey of riders: 97% experience riding MAX as "good" or "excellent." 57% "appearance/design of MAX stations" as "excellent." 66% "appearance/design of MAX vehicles" as "excellent."

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Boulder Highway Express	Operating	http://www.rtcsnv.com/			Regional Transportation Commission of Southern Nevada (RTC)		Las Vegas	NV
Henderson and Downtown Express	Operating	http://www.rtcsnv.com/			RTC		Las Vegas	NV
Sahara Avenue	Implementing	http://www.rtcsnv.com/			RTC		Las Vegas	NV
The Rapid	Operating	http://www.wheelsbus.com/index.aspx?page=79			Livermore Amador Valley Transit Authority (WHEELS)		Livermore	CA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Boulder Highway Express		Mixed traffic			12		CNG, diesel hybrid electric
Henderson and Downtown Express					10		CNG, diesel hybrid electric
Sahara Avenue	17						CNG, diesel electric hybrid
The Rapid	16	Mixed traffic		Yes	50	14	Hybrid Electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Boulder Highway Express		AVL, Real time information (Internet), Cameras (Vehicles), Smart card techniques		20	20	20	20
Henderson and Downtown Express		AVL, Real time information (Internet), Cameras (Vehicles), Smart card techniques		30	30	30	30
Sahara Avenue		AVL, TSP, Real time information (Internet, stations), Cameras (Vehicles), Smart card techniques		15	30	15	30
The Rapid	level-boarding	AVL, APC, real time information (Stops, internet), cameras (Vehicles), TSP, smart card techniques		10	15	10	15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Boulder Highway Express			Proof of Payment, Ticket vending machines				
Henderson and Downtown Express			Proof of Payment, Ticket vending machines, farebox				
Sahara Avenue	15-20 (est)		Proof of Payment, Ticket vending machines				
The Rapid			On-board far box				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Boulder Highway Express							
Henderson and Downtown Express					40		
Sahara Avenue					24.9		
The Rapid					21		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
901 Metro Orange Line	Operating	http://www.metro.net/service/lines/901/		2005	Los Angeles County Metropolitan Transportation Authority	Link North Hollywood, Van Nuys, Canoga Park, and Chatsworth	Los Angeles	CA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
901 Metro Orange Line	14.5	13.45 miles Dedicated transitway on rail ROW; 1.03 miles of mixed flow lanes			28	30	CNG

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
901 Metro Orange Line		AVL, Real time information (Internet), Cameras (Vehicles), Smart card techniques, TSP,	4AM-12AM Everyday; Service cover Late Friday and Saturday night	4	7	4	8

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
901 Metro Orange Line	18.1	33000 in 2012 (23156 in 2012)(21000 six months after opening)	proof of payment, ticket vending machine				17%

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
901 Metro Orange Line		Yes	2days	Metro staff attributed a few development projects to the presence of Metro Rapid lines, but noted that other factors have likely influenced most of the development. For instance, many Metro Rapid routes are already developed because they tend to follow the city's old streetcar routes, which concentrated development in these corridors. In addition, they told us that the BRTs run on busy streets that the city has been targeting for more density anyway.	$318 (gobrt breakdown)	No FTA funding. State on Congestion Relief Program (TCRP): $145.5 million. State Regional Improvement Program: $300,000. Local Prop C Transit: $168.4 million	A January 2006 rider survey found that riders overwhelming approve of Orange Line features and time-savings: 95% indicated that they like the Orange Line Metroliner vehicle, 91% like the pre-paid boarding system. 92% normally have a seat for the trip

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Metro Rapid	Operating	http://www.metro.net/projects/rapid/	1999	2000	Los Angeles County Metropolitan Transportation Authority	multiple lines. Demonstration Proragm was implemented in two key corridors	Los Angeles	CA
South Miami-Dade Busway (No distinguishing logos)	Operating	http://www.miamidade.gov/transit/south-miami-dade-busway.asp		1997 (extended in 2005 and 2007)	Miami-Dade Transit	Metrorail with Cutler Ridge, Naranja and Florida City	Miami	FL

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Metro Rapid		mixed traffic					Diesel fuel, diesel hybrid technology or CNG
South Miami-Dade Busway (No distinguishing logos)	20	Dedicated	Two way two lane exclusive roadway on the right-of-way of previous Florida East Coast Railroad line		30	57	diesel fuel, diesel-hybrid technology or CNG

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Metro Rapid	level-boarding	real time information (stations)		3-10		3-10	
South Miami-Dade Busway (No distinguishing logos)	Level Boarding	AVL, CAD,	local and limited-stop service; multiple routes	3	10	3	10

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Metro Rapid				40%		29%	33% new riders
South Miami-Dade Busway (No distinguishing logos)	15	25000 (2012)	On board fare box	23000 average weekday boarding in 2007. 179%	1997-2007		

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Metro Rapid							
South Miami-Dade Busway (No distinguishing logos)					58.36(8.5+6.5 miles)		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Metro Red Line/Cedar Avenue BRT	Operating	http://www.mvta.com/Bus_Rapid_Transit.html		2013	Minnesota Valley Transit Authority	the communities of Lakeville, Apple Valley, and Eagan to the Mall of America (MOA), MSP Airport, and downtown Minneapolis (via Blue Line connection at the MOA)	Minneapolis/Saint Paul	MN

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Metro Red Line/Cedar Avenue BRT	16	11 miles bus-only shoulder lane, and will cover the rest 5 miles too	bus-only shoulder lane		6	12	Hybrid Electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Metro Red Line/Cedar Avenue BRT		AVL, real time information (Stations, vehicles, internet), TSP, smart card techniques	5AM-11PM on Weekdays; 7AM-11AM on Weekends and Holidays	15	15	20	20

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Metro Red Line/Cedar Avenue BRT		835 (2013 august, 2 month after opening; 86% of the goal by the end of the first year of service 975, and halfway toward its 2017 goal 1600)	Ticket Vending Machine				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Metro Red Line/Cedar Avenue BRT	Adults (1.75 non-rush; 2.25 rush); Senior, Youth, medicare card holders (0.75 non-rush; 2.25 rush) ;Disabilities (.75)	Y	First week		112 in total ;Required federal funding 40.6		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
CTfastrak (New Britain-Hartford Busway)	Implementing	http://www.ctfastrak.com/	1997	2015	CT Transit	on I-84 between Hartford, West Hartford, Newington and New Britain	New Britain	CT

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
CTfastrak (New Britain-Hartford Busway)	9.4	Dedicated busway: follow the route of an abandoned rail right-of-way (the "Newington Secondary") from downtown New Britain to near the former Newington Junction station. It will then run parallel to the current Amtrak rail line	Grade-seperated limited-access highway		11	10	Diesel electric hybrid

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
CTfastrak (New Britain-Hartford Busway)	level Boarding	AVL, real time information (Stations, vehicles), Cameras (Vehicles), TSP, smart card techniques		3-6	15	3-6	15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
CTfastrak (New Britain-Hartford Busway)		16000 (Est.)	Proof of payment, ticket vending machines				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
CTfastrak (New Britain-Hartford Busway)					Total $ 567,053,000 (Professional Services $ 122,823,000 Construction $ 342,410,000 ROW $ 45,143,000 Buses $ 20,464,000 Contingency $ 23,245,000 Finance Charges $ 12,968,000)	Federal – New Starts $ 275,300,000 Federal – Other $ 179,542,399 State $ 112,210,601Federal – New Starts $ 275,300,000 Federal – Other $ 179,542,399 State $ 112,210,601	

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Marq2	Operating	http://metrotransit.org/marquette-and-2nd-avenues	2006	2009	Metro Transit	downtown Minneapolis	Minneapolis	MN
Route 56 Gallatin Road BRT Lite	Operating	http://www.nashvillemta.org/		2009	Nashville Metro Transit Authority	Music City Central to the edge of Sumner Cnty (north of RiverGate Mall)	Nashville	TN
Route 905 BUSPLUS	Operating	http://www.cdta.org/iride_projects_detail.php?id=7		2011	Capital District Transportation Authority (CDTA)	downtown Albany and downtown Schenectady	New York	NY

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Marq2		Dedicated (weekday 6-9am, 3-7pm), using original contraflow bus lanes	Two lane side-by-side on one way street, contraflow				
Route 56 Gallatin Road BRT Lite	12	Mixed traffic			15	7	Hybrid Electric
Route 905 BUSPLUS	17	Mixed Traffic			18 (36)	15	Hybrid Electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Marq2							
Route 56 Gallatin Road BRT Lite		AVL, Real time information (Internet), Cameras (Vehicles), Smart card techniques, TSP		15	15	15	30
Route 905 BUSPLUS		AVL, APC, real time information (Stations, internet), cameras (Vehicles), TSP, smart card techniques	5:00AM-11:30PM on Weekdays; 7:00AM-10:00PM on Sat; 8:00AM-5:00PM on Sun	15	30	15	30

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Marq2				0.1814346	2 years		
Route 56 Gallatin Road BRT Lite	14	1800	On board fare box				
Route 905 BUSPLUS	N/A	12000	Proof of payment. Ticket vending machines	13%	11 months	25%	

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Marq2							
Route 56 Gallatin Road BRT Lite	$1.6				10		
Route 905 BUSPLUS		Y	14		36.5		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
M15 First/Second Avenues SBS (Selectbusservice)	Operating	http://web.mta.info/mta/planning/sbs/2ave.html	2006	2010	Metropolitan Transportation Authority (MTA)	South Ferry and 125th Street	New York	NY
M34/M34A SBS	Operating	http://web.mta.info/mta/planning/sbs/34st.html	2004	2008	Metropolitan Transportation Authority (MTA)	12th Avenue and East 34th Street Ferry Terminal	New York	NY
Bx12 Fordham Road SBS	Operating	http://web.mta.info/mta/planning/sbs/bx12.html		2008	Metropolitan Transportation Authority (MTA)	Broadway-Inwood and Bay Plaza	New York	NY

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
M15 First/Second Avenues SBS (Selectbusservic e)	8.5	Semi-dedicated: dedicated lanes sharing with right-turn vehicles, pick-up/dropoff activities, access drive ways	Offset bus lanes; curbside bus lanes during 7-10am, 2-7pm; NB on 1st Ave, SB on 2nd Ave		35	48	Hybrid Electric
M34/M34A SBS	2/2.5	semi-dedicated busway			13/20		Hybrid Electric
Bx12 Fordham Road SBS	9	semi-dedicated busway; mixed traffic			18	32	Hybrid Electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
M15 First/Second Avenues SBS (Selectbusservic e)	level-boarding	AVL, APC, real time information (Stops, vehicle), cameras(Vehicle),TSP, smart card techniques	5:00AM-10:00PM with local service 24/7	5	10	5	10
M34/M34A SBS	level-boarding	AVL, APC, real time information (Stops, vehicle), cameras(Vehicle),TSP, smart card techniques	5AM-1AM everyday	6/7	8/9	7/10	10(20)
Bx12 Fordham Road SBS	level-boarding	AVL, APC, real time information (Stops, vehicle), cameras(Vehicle),TSP, smart card techniques	5AM-11PM with local service 24/7	5	10	5	10

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
M15 First/Second Avenues SBS (Selectbusservice)	10	57000 (2012), 35000(2011)	Proof of payment, ticket vending machine	9%; 42%	2010-11; 2011-2012	15-18% (in one year)	
M34/M34A SBS		18000 in total (2012); 22000 in total (2013)	Proof of payment, ticket vending machine			10% till 2012	
Bx12 Fordham Road SBS		46000	Proof of payment, ticket vending machine	7%	1 year	19% compared to B*12 limited	

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
M15 First/Second Avenues SBS (Selectbusservic e)					92.1		2011, Among those interviewed on the SBS, 99% are "satisfied" or "very satisfied"; among M15 Local bus riders, this figure is 90%
M34/M34A SBS							
Bx12 Fordham Road SBS					10.5		95% of customers responded that they were satisfied or very satisfied with their average wait time for the SBS

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Line 72R San Pablo Rapid	Operating	http://www.actransit.org/planning-focus/your-guide-to-bus-rapid-transit/brt-project-status/			AC Transit	from Contra Costa College in San Pablo to downtown Oakland (along San Pablo Ave.), and on to Jack London Square along Broadway.	Oakland	CA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Line 72R San Pablo Rapid	14	mixed traffic			26		

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Line 72R San Pablo Rapid	level boarding	AVL, APC, real time information(stops), TSP		12	12	12	12

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Line 72R San Pablo Rapid		6050	On board fare box	2.60%	17months (since May 2003)	17% (compared to limited stop service)	

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Line 72R San Pablo Rapid					3.2		Travel time 4.3/5, Overall satisfaction 4.2

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Line 1R International Rapid	Operating	http://www.actransit.org/planning-focus/your-guide-to-bus-rapid-transit/		2012	AC Transit	UC Berkeley to downtown Oakland along Telegraph Ave. and on to Bay Fair BART in San Leandro along International Blvd. and East 14th St.	Oakland	CA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Line 1R International Rapid		mixed traffic					

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Line 1R International Rapid	level boarding	AVL, APC, real time information(stops), TSP		12	12	12	12

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Line 1R International Rapid			On board fare box				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Line 1R International Rapid							

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
East Bay BRT	Implementing	http://www.transformca.org/bay-area-transportation/brt/east-bay		2016	AC Transit	Downtown San Leandro to Downtown Oakland	Oakland	CA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
East Bay BRT		81 % is dedicated lane	most is median aligned, partly is curb-aligned				

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
East Bay BRT	level-boarding	TSP,		5	5	5	5

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
East Bay BRT			off board payment; provide on board fare box				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
East Bay BRT					174	Regional Measure 2: 43.4 for cons. (3 annually O&M); AlamedaCnty Measure B: 5.5 for cons.; Fed. Small Starts: 75 (Anticipated); State Trans. Impro.Program 40; Fed. Sec. 5309 Bus: 3.1 for cons.; AC Transit bus procurement program funds - 4.9	

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Lynx Lymmo	Operating		1997		Orlando Lynx		Orlando	FL
Main Street LINK	Operating	http://www.valleymetro.org/vm/link_intro			Regional Public Transportation Authority (Valley Metro)		Phoenix	AZ

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Lynx Lymmo	3	Dedicated	Busways that are split into two one-way pairs and aligned to the curb		11		Hybrid Electric
Main Street LINK	13	Mixed traffic			15	10	Diesel

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Lynx Lymmo		AVL, APC, real time information(Stops, vehicles), TSP	Monday – Thursday: 6 a.m. – 10 p.m. Friday: 6 a.m. – midnight Saturday: 10 a.m. – midnight Sunday: 10 a.m. – 10 p.m	5	10	5	10
Main Street LINK		AVL, APC, real time information(Stops), cameras(Vehicles), TSP, smart card collection techniques		15	30	15	30

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Lynx Lymmo		5000					
Main Street LINK	25	1174	On board fare box, ticket vending machine				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Lynx Lymmo		Yes	Since openning till now		21	O&M is funded by the city of Orlando's Downtown Development Board and Parking Division	
Main Street LINK					20		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
West Busway (G)	Operating	http://www.pittsburghtransit.info/busway.html; http://www.portauthority.org/paac/CompanyInfoProjects/BusRapidTransit.aspx		2000	Port Authority of Allegheny County	downtown Pittsburgh to Carnegie	Pittsburgh	PA
South Busway (Y)	Operating	http://www.pittsburghtransit.info/busway.html		1977	Port Authority of Allegheny County	downtown and South Hills	Pittsburgh	PA
East Busway (P)	Operating	http://www.pittsburghtransit.info/busway.html		1983;2003	Port Authority of Allegheny County	between Downtown and eastside communities	Pittsburgh	PA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
West Busway (G)	5	two lane dedicated bus-only highway			6	920 (Total Fleet)	CNG
South Busway (Y)	4.3	dedicated lane through trolley right-of-way; bypass traffic congestion on the Liberty Bridge and Tunnel through a joint-use bus/light rail transit tunnel	two lane		8	920 (Total Fleet)	CNG, clean diesel
East Busway (P)	6.8+2.3	two lane dedicated bus-only highway parallel to railroad ROW	two way two lane		10	920 (Total Fleet)	CNG, hybrid electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
West Busway (G)		Real time information(Stops, vehicles), TSP, smart card techniques, vehicle guidance and control	5AM-11PM on Weekdays; 6AM-11PM on Sat; 6:30AM-11:00 PM on Sun	15	15	15	15
South Busway (Y)		TSP, real time information (vehicles)	multiple routes	15	20	15	20
East Busway (P)		TSP, real time information (vehicles		6	12	6	12-20

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
West Busway (G)	55		On board fare box	3772 (august 2000)-8732 (oct2002) : 135%	26months		
South Busway (Y)	40	13000	On board fare bax				
East Busway (P)	35	28000	On board fare bax			from downtown and Wilkinsburg from 45 to 15 minutes (1983)	

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
West Busway (G)					326.8		Yes. 85% riders reported total travel time has been reduced by an average of 14 minutes
South Busway (Y)					27		
East Busway (P)					115 (1983)+68.8(1999)	Extension $68.8million, FTA funded 80%, State and county paid the rest.	

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
sbX	Implementing	http://www.estreet-sbx.com/		2014	Omnitrans	northern San Bernardino and Loma Linda	San Bernardino	CA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
sbX	15.7	30% dedicated lane (5.4miles)	center dedicated lane		16	14	CNG

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
sbX	Level Boarding	AVL, real time information (Stations, vehicles), Cameras (Vehicles), TSP, smart card techniques		10	15	10	15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
sbX			Proof of payment, ticket vending machines				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
sbX					191.7 in total. 75 FTA Small Starts; 45.62 FTA Urbanized Area Formula; 21 Fed.Hwy Flexible Funds for CMAQ; 14.34 from Proposition 1B Bonds; 5.48 from SanBernardino Cnty Measure I, the voter-approved half-cent sales tax		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
3500 South Max	Operating	http://www.rideuta.com/mc/?page=UTA-Home-MAX		2008 (2010 dedicated lane)	Utah Transit Authority	along 3500 South between the 3300 South TRAX Station and Magna	Salt Lake City	UT
Mid-City Rapid	Implementing	http://www.sandag.org/index.asp?projectid=317&fuseaction=projects.detail		2014	SANDAG	between San Diego State University and Downtown San Diego via El Cajon and Park boulevards	San Diego	CA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
3500 South Max	10	a mile dedicated guideway between Constitution Boulevard and Bangerter Highway	dedicated lane center aligned		12	7	Diesel
Mid-City Rapid	10	0.5 mile of dedicated lane on Park Boulevard	dedicated lane is median aligned				

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
3500 South Max	level Boarding	AVL, APC, real time information (Stations, internet), TSP, smart card techniques	4:20AM-10:30PM on Weekdays; 5:00AM-11:00PM on Sat; no service on Sun	15	15	15	15
Mid-City Rapid	level Boarding	TSP		10	15	10	15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
3500 South Max		4400 (2012)	Ticket Vending Machine	100% (4100 ppl in 2010 on MAX doubled the number of the replaced Route 37)			
Mid-City Rapid							

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
3500 South Max	2.5				initiate 7+ dedicated lane 8		
Mid-City Rapid					Budget is $44	Half of the cost is funded by the regional half-cent sales tax for transportation called TransNet. The other half (21.65) comes from a federal grant.	

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
I-15 BRT	Implementing	http://www.sandag.org/index.asp?projectid=393&fuseaction=projects.detail		2014	SANDAG; Metropolitan Transit System (MTS)	Escondido Transit Center and downtown San Diego	San Diego	CA
South Bay BRT	Implementing	http://www.sandag.org/index.asp?projectid=297&fuseaction=projects.detail		2015	SANDAG	from the Otay Mesa Port of Entry to Downtown San Diego via eastern Chula Vista	San Diego	CA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
I-15 BRT	20	semi-dedicated lane/ using I-15 four lane express lane	express lane in the median of I-15; moveable barrier			27	
South Bay BRT	21	over half of the length is semi-dedicated lane/using I-805 HOV lane			11		

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
I-15 BRT	level-boarding	smart card		10	15	10	15
South Bay BRT				10	15	10	15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
I-15 BRT			on-board				
South Bay BRT							

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
I-15 BRT					total cost including expansion of FasTrak and the transit element is $1.4 billion. BRT elements are $246	required federal funding 4.18;	
South Bay BRT					required federal funding 114;		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Van Ness BRT	Implementing	http://www.sfcta.org/delivering-transportation-projects/van-ness-avenue-bus-rapid-transit-home	2004	2018	SFCTA		San Francisco Bay	CA
Metro Express	Operating	http://sanjoaquinrtd.com/express/					San Joaquin	CA
BRT	Implementing	https://www.scgov.net/BRT/Pages/default.aspx	2006		Sarasota County Area Transit		Sarasota	FL
B Line – Bellevue/ Redmond	Operating	http://metro.kingcounty.gov/travel-options/bus/rapidride/b-line/		2011	King County Metro Transit		Seattle	WA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Van Ness BRT		Dedicated bus lane from Lombard to Mission streets	Dedicated lane is median aligned				
Metro Express		Mixed traffic					
BRT							
B Line – Bellevue/ Redmond	10	Mixed traffic			46	18	Hybrid Electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Van Ness BRT	level-boarding	TSP, traffic signal optimization					
Metro Express				10	30	10	30
BRT							
B Line – Bellevue/ Redmond	level-boarding	AVL, APC, real time information (Stations), Cameras (Vehicles), TSP, smart card techniques		10	15	10	15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Van Ness BRT							
Metro Express			Off board fare collection				
BRT							
B Line – Bellevue/ Redmond							

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Van Ness BRT					required federal funding 70.04;		
Metro Express							
BRT						no funding allocated	
B Line – Bellevue/ Redmond					190		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
RapidRide - A Line	Operating	http://www.kingcounty.gov/transportation/kcdot/NewsCenter/Reports/RapidRideFactSheet.aspx?print=1		2010	King County Metro Transit	Linking SeaTac and Federal with many public facilities along the route and ending at two major connection points: Federal Way Transit Center and Tukwila International Blvd. Station	Seattle	WA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
RapidRide - A Line	11	HOV line			51	16	Hybrid Electric

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
RapidRide - A Line	level-boarding	AVL, APC, real time information(Stops), cameras(Vehicles), TSP, smart card collection techniques	24/7	10	15	10	15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
RapidRide - A Line	4.1	7500 (2011 January, three month after opening)	On board fare box, proof of payment	25	3 month after opening (2010 Oct)		

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
RapidRide - A Line				Local officials told us development along the RapidRide A has been limited, but some developers are interested in the corridor, in part because of complimentary planned light rail service. In addition, they noted that other BRT corridors in the region are attracting transit-oriented development and that BRT will eventually connect most of the region's significant growth centers.	budget for first six lines is 215. The budget includes: Corridor and roadway improvements 50; Passenger facilities 35; Buses (113) 128.	federal 14.08 (with 20 pending), state 46,	84% (3month after opening)

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Stamford Urban Transitway	Implementing	http://www.stamfordct.gov/engineering-department/pages/stamford-urban-transitway		Phase 2:2015	CTTransit		Stamford	
Metro Rapid (North-South)	Operating	http://www.gohart.org/metrorapid/		2013 (late May)	Hillsborough Area Regional Transit Authority (HARTline)		Tampa	Fl

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Stamford Urban Transitway	1+0.75	Semi-dedicated lane (HOV)					
Metro Rapid (North-South)	17.5	Mixed traffic			59	12	

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Stamford Urban Transitway							
Metro Rapid (North-South)	level-boarding	AVL, real time information (Stations, vehicles), Cameras (Vehicles), TSP, smart card techniques		15	15	15	15

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Stamford Urban Transitway							
Metro Rapid (North-South)	19	1000(2013 May), 1929(2013June)	Proof of payment, ticket vending machines			15% compared to traffic	

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Stamford Urban Transitway					Phase 1 total 65; Phase 2 estimated 51.9	Phase 1 funded through FTA & City of Stamford; Phase 2 required federal funding 24.72	
Metro Rapid (North-South)	2	Y	First two weeks		25.3	Hillsborough County Community Investment Tax funded the design and construction phases of the MetroRapid N-S project	

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
RTC RAPID	Operating	http://www.rtcwashoe.com/public-transportation-76		2009	Regional Transportation Commission of Washoe County (RTC)		Washoe County	NV
Silver Streak (El Monte Busway)	Operating	http://www.foothilltransit.org/FareTypesCharts/		2007	Foothill Transit	Montclair and Los Angeles	West Covina (San Gabriel and Pomona) Valleys	CA

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
RTC RAPID	4.2	Mixed traffic			14	7	Hybrid Electric
Silver Streak (El Monte Busway)	40	Mixed traffic on freeways and 18 miles of HOV lanes			20	N/A	CNG

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
RTC RAPID	Level Boarding	AVL, Real time information (Internet), Cameras (Vehicles), Smart card techniques, green extension		10	20	10	30
Silver Streak (El Monte Busway)		AVL, APC, real time information(Bus), TSP		10	20	10	20

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
RTC RAPID	11.3	3000	On board fare box, ticket vending machine	15% (09nov-10June); 5.4%(10-11)			
Silver Streak (El Monte Busway)	N/A	4700	On board fare box, proof of payment				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
RTC RAPID					20		
Silver Streak (El Monte Busway)	2.45 (interaction with Metro Silver Line"	Y	First two weeks		28		

Table 25 (Continued)

Route	Stage	Website	Year of Starting Plan	Year of Opening	Agency	Connecting	City	State
Division Avenue BRT/SilverLine	Implementing	http://www.ridetherapid.org/futureplanning/silverline	2002	2014	Interurban Transit Partnership	along Division Avenue from the Grand Rapids central business district (CBD) to 60th Street/Division Avenue	Grand Rapids, Kentwood, and Wyoming	MI

Table 25 (Continued)

Route	Total Lengh (Miles)	ROW	Alignment	Queue Jumper	Number of Stations	Number of BRT Vehicles	Propulsion System
Division Avenue BRT/SilverLine	9.8	Semi-dedicated lane sharing with right-turn vehicles	curb-side		33	10	Hybrid-fueled

Table 25 (Continued)

Route	Boarding	Intelligent Transportation System Technologies	Service Span	AM Peak Headway	AM Off Peak Headway	PM Peak Headway	PM Off Peak Headway
Division Avenue BRT/SilverLine	Level Boarding	real time information, TSP,		10	20	10	20

Table 25 (Continued)

Route	Average Operational Speed (MPH)	Average Weekday Ridership	Fare Payment Method	% Corridor Ridership Gain	Ridership Gain Time Period	Maximum % Reduction in Travel Time	% BRT Ridership that is New Transit Trips
Division Avenue BRT/SilverLine			ticket vending machine				

Table 25 (Continued)

Route	Fee	Free Fee	Free Fee Period	Summary of Economic Development	Capital Cost (million)	Funding (million)	Custom Satisfaction
Division Avenue BRT/SilverLine					35.285: Guide.&Trackwork1.799; Sta&Stops& Termin. 8.526; Supp.Fac. .316;Sitework and Spec. Cond. 1.081;Systems6.469;ROW, Land, Impro.0.709; Vehicles8.326;Professional Services6.002; Contingency 1.091;Fina. Char..966	FTA Very Small Starts, $28.228, State of Michigan $7.057	

REFERENCES

Agrawal, Asha Weinstein, Todd Goldman, and Nancy Hannaford. 2012. Shared-use Bus Priority Lanes on City Streets: Case Studies in Design and Management. Mineta Transportation Institute.

ALC-BRT, and EMBARQ. 2013. *BRT Data in United States* 2013a [cited March 20 2013]. Available from http://www.brtdata.org/#/location/northern_america/united_states.

ALC-BRT, and EMBARQ. 2013b. United States BRT Data.

ARC. 2007a. County Profile: COBB; Older Adults in the Atlanta Region: Preferences, Practices and Potential of the 55+ Population.

ARC. 2007b. County Profile: DEKALB; Older Adults in the Atlanta Region: Preferences, Practices and Potential of the 55+ Population.

ARC. 2007c. "County Profile: FULTON; Older Adults in the Atlanta Region: Preferences, Practices and Potential of the 55+ Population."

ARC. 2007d. County Profile: GWINNETT; Older Adults in the Atlanta Region: Preferences, Practices and Potential of the 55+ Population.

ARC. 2011. "Regional Travel Survey Final Report."

AtlantaStreetcar. 2013. Atlanta Streetcar Fact Sheet.

BTI. 2013. *WORLDWIDE BRT DATABASE* 2008 [cited July 20 2013]. Available from http://www.gobrt.org/database.

Carey, Graham. 2006. "Bus Rapid Transit—The Eugene-Springfield, OR, USA, Experience." *ITE Journal* no. 76 (7):20-23.

Copeland, Larry. 2013. "Young people driving less, embrace other transportation." *USA TODAY*, October 1.

EMBARQ. 2013. *EMBARQ* 2013 [cited March 21 2013]. Available from http://www.embarq.org/.

Finn, Brendan, Odile Heddebaut, Arno Kerkhof, François Rambaud, Oscar Sbert Lozano, and Claude Soulas. 2011. Buses with High Level of Service

Fundamental characteristics and recommendations for decision-making and research

Results from 35 European cities. European Cooperation in Science and Technology.

Helen M.Tann, Dennis Hinebaugh. 2009. Characteristics of Bus Rapid Transit for Decision-Making. Federal Transit Administration, National BRT Institute

ITDP. 2012. The BRT Standard Version 1.0. Institute for Transportation & Development Policy.

ITDP. 2013. The BRT Standard 2013.

Ivany, David R. 2004. "Bus Rapid Transit on the Streets of Boston, MA, USA - Making It Fit." *ITE Journal* no. 74 (6):42-45.

JB. 2009. BRT Lite--another half-assed transit solution? In *Imagine Title Here*.

Johnson, Tim, and Richard C. Shelby. 2012. BUS RAPID TRANSIT Projects Improve Transit Service and Can Contribute to Economic Development. edited by United States Government Accountability Office.

Kimbler, Jim. 2005. "Bus Rapid Transit in Downtown Orlando, FL, USA." *ITE Journal* no. 75 (2):40-42.

Levinson, Herbert S., Smuel Zimmerman, Jennifer Clinger, James Gast, Scott Rutherford, and Eric Bruhn. 2003. "Transit Cooperative Research Program (TCRP) Report 90: Bus Repid Transit Volume 2: Implementation Guidelines." *TCRP Report*.

Levinson, Herbert, Samuel Zimmerman, Jennifer Clinger, Scott Rutherford, Rodney L. Smith, John Cracknell, and Richard Soberman. 2003. Volume 1: Case Studies in Bus Rapid Transit. In *Bus Rapid Transit*: Tranportation Research Board.

Liu, Zichang, Xiaoning Zhang, and Hua Wang. 2013. Lessons of bus rapid transit from nine cities in China. In *TRB 92nd Annual Meeting*. Washington.

MARTA. 2011. Minutes: Meeting of the Board of Directors Customer Development Committee. edited by MARTA.

NBRTI. 2012a. Currently Implementing.

NBRTI. 2012b. Currently Operating BRT.

NBRTI. 2013. *"What is Bus Rapid Transit?"* 2013 [cited March 10 2013]. Available from http://www.nbrti.org/.

NuStats, PTV, and GeoStats. 2011. 2011 Household Travel Survey edited by ARC and GDOT.

Rabuel, Sebastien, Odile Heddebaut, and Brendan Finn. 2010. Bus with a High Level of Service (BHLS): European BRT Concept. In *Transportation Research Board 89th Annual Meeting*. Washington DC.

Reed, Dan. 2012. LA's Orange Line shows the way for Montgomery BRT. In *Greater Greater Washington*.

Roy, Joyce 2013. *BRT-lite* 2008 [cited April, 4 2013]. Available from http://www.smartvoter.org/2008/11/04/ca/alm/vote/roy_j/paper1.html.

Samuel, Peter. 2011. "GA/I-85 Express Lanes' wild start - tolls too high, lanes near empty, Governor steps in." *Toll Roads News*, October 8, 2011.

Saporta, Maria. 2013. "Metro Atlanta Speaks survey shows strong support for public transit." *Saporta Report*, November 1.

SFMTA. 2012. Introducation of Geary BRT Project.

TCRP. 2007. Transit Cooperative Research Program (TCRP) Report 118: Bus Rapid Transit Practitioner's Guide. Transportation Research Board.

Vozzolo, David. 2012. "MAP-21 New Starts, Core Capacity and Small Starts."